Drosophila suzukii (Matsumura), a revolution for soft fruits in Trentino

A.Grassi, M.Pallaoro [1]

Abstract

In September 2009, Spotted Wing Drosophila (SWD), Drosophila suzukii *(Matsumura), was detected for the first time in Italy and Europe on raspberry (*Rubus idaeus *L.), highbush blueberry (*Vaccinium corymbosum *L.) and strawberry (*Fragaria x ananassa *Duch.) in several cultivated fields in Trentino, north-eastern Italy. Two years after, SWD reached an extraordinary population development, causing serious damages on cherries and soft fruits: an important infestation was also observed for the first time on wine grape. Due to the very high pest pressure, conventional insecticides, even if applied many times at the harvest, were unsuccessful in reducing the fruits damage at acceptable levels. Interesting results were obtained with alternative control methods, such as the mass trapping and the anti-insect nets. A multi-method approach seems to be the best to manage* D.suzukii *infestations in a sustainable way in Trentino region.*

Keywords: Spotted Wing Drosophila, *Drosophila suzukii*, soft fruits, mass trapping, anti-insect nets

Introduction

The Spotted Wing Drosophila, *Drosophila suzukii* (Matsumura) is one of the two species of the genus *Drosophila* to lay eggs in healthy (whole) fruits instead of damaged or overripe ones (Sasaki and Sato 1995, 1996). It preferentially oviposits on mature fruits but can also lay eggs on immature and spoiled fruit of suitable varieties at lower rates (Kanzawa 1939; Mitsui *et al.* 2006).

The larval feeding causes the fruit to collapse around the oviposition site. The oviposition scar exposes the fruit to secondary attack by pathogens and other insects (Hauser and Damus 2009). The damage caused by *Drosophila suzukii* larvae renders the fruit unsuitable for sale.

The pest was recorded for the first time in Trentino, north-eastern Italy, in September 2009. Soft fruits and strawberry production is an important component of agriculture in our region, where these fruits showed a high intrinsic susceptibility to *D.suzukii* infestations, probably because of their long harvest period, the thin skin and a sweet juicy pulp.

In 2010, we carried out a monitoring study, field and lab surveys to better understand the distribution of the pest on our territory, to deepen its biology and seasonal phenology, to determine the host range (cultivated and spontaneous) and to assess the efficacy of registered conventional insecticides in controlling SWD infestations.

The insecticides must be used during the ripening period of the fruits, to kill the adults and to prevent so the egg laying inside the ripe fruits, the most susceptible stage. For several aspects, this approach is very complicated on soft fruits: they are harvested over a long period and at very short intervals, so that it's very difficult to correctly time the sprays complying with the pre-harvest interval. Moreover, the repeated applications of insecticides can cause serious commercial problems due to the accumulation of residues on the product, are unsustainable over a long period for the negative impact on the environment

[1] Alberto Grassi, Marica Pallaoro, Fondazione E.Mach/IASMA, 38010 S.Michele a/A, Italy, alberto.grassi@iasma.it

and on the IPM on soft fruits, on the health of growers and consumers, and may lead to resistance problems in the SWD populations.

In 2011, we repeated the territorial monitoring and conducted some trials in order to evaluate the effectiveness of alternative control methods, like the mass-trapping and the anti-insect nets.

Material and Methods

Monitoring of SWD adult flight activity. To determine the distribution of the pest on the territory and the seasonal adults activity, we used 65 apple cider vinegar traps. A trap consisted of a durable plastic bottle of 500-1000 ml capacity with a screw-top. Six 0.6 mm diameter holes were drilled on the side and 200 ml of pure apple cider vinegar were added as a bait.

The traps (one per site, hung on shady side of the plant) were deployed since the beginning of April (week 14) or beginning of May (week 19) till the beginning of December (week 49) in some woody areas, fields of highbush blueberry, raspberry, blackberry and strawberry and orchards of sweet cherry, apricot, wine grape. In some cases, traps placed on site in 2010 were regularly inspected also during the winter and the 2011 season.

Traps were replaced once a week, the solution was filtered in laboratory and males and females were counted under dissecting microscope. Some of the traps are still now on place in order to document the flight of the adults during the winter time, and will remain till the next season.

Fruits infestation assessment. In most of the sites where the adults flight was monitored, the infestation on fruits was weekly estimated during the harvest time on a sample of 50-100 soft fruits/site (25-50 cherries and apricots/site), collected at the right commercial ripening stage from an area of about 15-20 metres diameter around the trap. On wine grape, 10 bunches/site were sampled at the harvest time from the edges of the vineyard close to woods or bushy borders and we inspected 10-15 berries/bunch.

A total of 739 samples were inspected. Fruits were accurately examined one by one under dissecting microscope, to search for the eggs of *D.suzukii*, typically inserted in the skin.

Mass-trapping trial. The aim of the trial was to evaluate the effectiveness of a dense barrier of traps deployed along the edges of a highbush blueberry plantation (var.Elliot – surface of about 800 square metres) in preventing the immigration of SWD adults and their damage on the fruits during a complete harvest period.

The traps, of the same type used for monitoring the SWD adults flight activity on the territory, were placed in the field prior to the reddening of the fruits (week 28 – 12 July). They were hung on the blueberry bushes on the borders at a distance of about 2 metres between them. A few traps were placed also on trees around the plantation and a control trap was deployed in the middle of the field. As a bait, we used a solution of 150 ml of pure apple cider vinegar and 50 ml of red wine per trap. The bait was weekly replaced until the end of the trial (week 34 – 22 August, end of harvest). The solution was filtered in lab and adult males and females were counted under dissecting microscope.

The damage on the fruits was weekly estimated on samples of 100 fruits (at the right commercial ripening stage) picked up both from the bushes on the edges and from the bushes in the central part of the field. The fruits were examined one by one under dissecting microscope, searching for the SWD eggs inserted in the skin.

Anti-insect nets. The aim of the trial was to assess the efficacy of nets (0.5 mm x 0.8 mm mesh size) in reducing the infestation of *D.suzukii* on the fruits of sweet cherry and highbush blueberry.

Two sweet cherry orchards (cv. Regina) were selected in the production areas of Vigolo Vattaro and Susà. The SWD adult flight was monitored using 2 apple cider vinegar traps in each orchard. Before the reddening of the fruits (week 22), five trees (about 4 metres tall) were randomly selected and singly bagged with a bag of net. The bag was closed on the base of the trunk with a rope. A control plot (5-10 trees), where insecticides were not applied for the control of *D.suzukii*, was arranged in a edge of each orchard. In addiction, some branches with fruits were protected during the insecticides sprays with a waterproof tissue, that was removed after the treatment to let the adults lay the eggs in the cherries. The infestation on fruits was assessed at the harvest time (week 27 and 28): samples of 50 cherries were collected from every bagged tree, from the control plot and branches and from the trees sprayed with the insecticides. The fruits were inspected in the lab under dissecting microscope, to search for the SWD eggs inserted in the fruits.

In a highbush blueberry plantation (cv. Brigitta) in Ronchi Valsugana site, two tunnels with nylon covering were singly completely wrapped on their sides with a band of the net, prior to the reddening of the fruits (week 24 – 15 June). An apple cider vinegar trap was placed in each tunnel and in a control plot (a tunnel where net and insecticides were not applied) to monitor the adults flight. The infestation was assessed at weekly intervals during the harvest on a sample of 100 fruits randomly collected at the right ripening stage from each of the tunnels covered with net, from the control plot and from the insecticides sprayed tunnels. The fruits were examined in lab under dissecting microscope to search for the SWD eggs. Meteo data (temperature and high humidity) were also recorded in covered and uncovered tunnels by means of dataloggers.

Results

Monitoring of the adults flight activity

Some adults were caught in apple cider vinegar traps during the winter time in few sites at different altitudes and situations. Most of them were collected in two lowland site, in S.Michele and Mezzocorona (Table 1). This means that the pest spent the winter as an adult (mainly females) directly on our territory. It's likely that a higher number of adults survived at lower altitudes, where temperatures are milder and the refugees are probably more abundant (houses, greenhouses, composters, etc.). The catches of adults in winter are probably due to adults that during particularly sunny days may fly away from the refugees, to search for food sources to maintain themselves during the winter.

No adults were collected by beatings, aspiration (on conifers, evergreen shrubs) and from dead leaves samples collected from raspberry and bluberry fields in winter and kept in lab till the next season.

The adults catches continued in spring in the two lowland sites. No adults were detected by means of beatings on wild and cultivated flowering *Prunus* and *Rosaceae* species.

The first *D.suzukii* eggs were found the 18th of May by visual inspection on cherry fruits collected from a wild tree in Roncogno (430 m a.s.l), near Pergine Valsugana. This was the first sign of the beginning of adults activity on the territory: in fact, the following weeks, we recorded the first adults in traps and some other eggs in fruits, always in cultivated sweet cherry orchards. These observations confirm that cherry is an important host for this pest, the first generations develop on it. To get a good control of the infestations on cherry is likely a crucial point to try to limit the development of the populations and the damages on the crops that will ripe later in the season.

What happened in the following period, summer and autumn, is really a dramatic population outbreak (Figure 1). Compared to 2010, the flight started about 2 weeks earlier: also the ripening of the susceptible crops was earlier and this better synchronism pest/crop

gave rise to a faster and more conspicuos demographic increase, with a peak in September much higher and earlier than the previous season. The climate in winter and spring was warmer than in 2010 and in addiction June was particularly rainy and humid. This positively affected the development of the pest, since *D.suzukii* seems to prefer high humidity conditions. Moreover, the rain damaged many cherries just at harvest time and many growers didn't harvest the fruits: from these fruits a lot of adults could develop and spread the infestations on the territory.

As in 2010, the pest was recorded everywhere in Trentino. It is interesting to observe that most of the adults were caught at medium-high altitudes (Figure 2): many soft fruits in Trentino are cultivated in this range, at the feet of the mountains and in lateral valleys, where also wild soft fruits are more abundant and the forests are closer to the crops. Also the climate at these altitudes is more suitable than in the bottom of the valleys, is milder during the summer, more rainy and more wet.

Fruits infestation

Cherries and strawberries are the first fruits that ripen in Trentino (Table 2). Cherries are the first host crop for *D.suzukii*. Most of the infested fruits recorded in May, June and July were sampled from unsprayed or rain unprotected orchards: in fact, in most of the cases, the insecticides on cherry were effective against SWD, probably because they were applied in a very early and susceptible stage of its population development. The insecticides showed to be ineffective where the cherry orchards were rain unprotected, because the residues were probably washed away. It is important to observe that cherry is highly susceptible to SWD: even if the adult population is still low, its damage on cherries may be severe if no chemicals are applied.

The strawberries harvested in May and June were undamaged, probably because cherry is more attractive than strawberry in this moment of the season. Moreover, the growers use to spray a lot of insecticides on strawberry, using different compounds: the population is still low in this stage and the chemicals are probably more effective. In any case, strawberry seems to be the least susceptible crop in Trentino.

Raspberry, blueberry and blackberry are highly susceptible crops. For the first season, we recorded also a quite severe and widespread infestation on wine grape: an earlier harvest and a better synchronism with the peak of adults population, were probably the main reason for this damage in 2011.

The highest levels of damage were recorded from July to October, with a peak in August-September. At that time, most of the infested samples had more than 50% of the fruits damaged.

For soft fruits the harvest period is much longer than on sweet cherry. Due to the very high pest pressure in 2011, a lot of adults could continuously immigrate into the fields from surrounding sites and lay the eggs in ripe and unripe fruits. Even if a lot of insecticides were applied during the harvest time, they were ineffective in controlling the infestation on fruits (Figure 3 and 4). These graphs suggest that we can not rely only on insecticides to get a good control of this pest in Trentino situation. Alternative control techniques and a multiple control methods approach are necessary.

The mass trapping trial showed quite promising results (Table 3). A very high number of adults was caught by the traps along the edges of the blueberry plantation during the trial, but just a few individuals were captured by the control trap in the middle of the field. Weekly catches demonstrate that males and females can continuously immigrate into the cultivated fields from external sources and that it's necessary to stop their incoming flight. The traps were successful for a long time in stopping this flight and preventing the infestation on the fruits in the centre of the field. Their effectiveness decreased just after

the peak of adults catches, almost close to the end of the harvest, when probably a higher number of adults was able to pass the traps barrier and lay more eggs in the fruits.

The anti-insect nets gave the best results in reducing the damage on the fruits. On cherry, we obtained 100% of efficacy in the trial carried out in the orchard in Susà site (Table 4). A single cherry fruit collected from a bagged tree, probably because in contact with the net, resulted infested with one egg in the trial performed in Vigolo Vattaro (Table 5).

It's interesting to observe that the insecticides applied by the growers against the Cherry Fruit Fly (*Rhagoletis cerasi*) at the fruit reddening phase in both the sites were unable to provide a protection against SWD, that occurred later. This means that with the available insecticides, generally provided with a short persistence of activity against *D.suzukii*, additional treatments in Trentino must be planned nearness the harvest to effectively control this pest, that prefers to attack fruits completely red and ripe. We expect that the number of insecticide sprays and their side effects will increase a lot on sweet cherry and this represent an important reason to exert every effort to find alternative control methods.

Also the trial on highbush blueberry produced promising results (Table 6). A weak infestation was recorded just at the end of harvest in one of the two tunnels protected with the net. We suspect that some adults got into the tunnels during the harvest procedures, when the pickers had to lift the net at the main openings to reach the bushes. This happened many times during the trial. No significant effects on climate (temperature and humidity) due to the net covering were recorded in this trial.

Table 1: Adults catches in apple cider vinegar traps during the winter time in 2011

site	S.Michele	Mezzocorona	Gaggio	V.Vattaro	V.Vattaro	Vattaro
crop	vineyard	small vineyard, garden	forest	forest	strawberry	forest
altitude (m a.s.l)	260	213	910	718	727	696
week n° and date	**SWD adults catches**					
2 - 10-16 January			1 ♂			
3 - 17-23 January	1 ♀	1 ♀				
5 - 31 Jan. - 6 Feb.	1 ♀	1 ♀				
9 - 28 Feb. - 6 Mar.				2 ♀		
10 - 7-13 March	4 ♀	4 ♀				
12 - 21-27 March	4 ♀	1 ♀			1 ♂ + 1 ♀	1 ♂
13 - 28 Mar. - 3 Apr.	1 ♀	1 ♀				

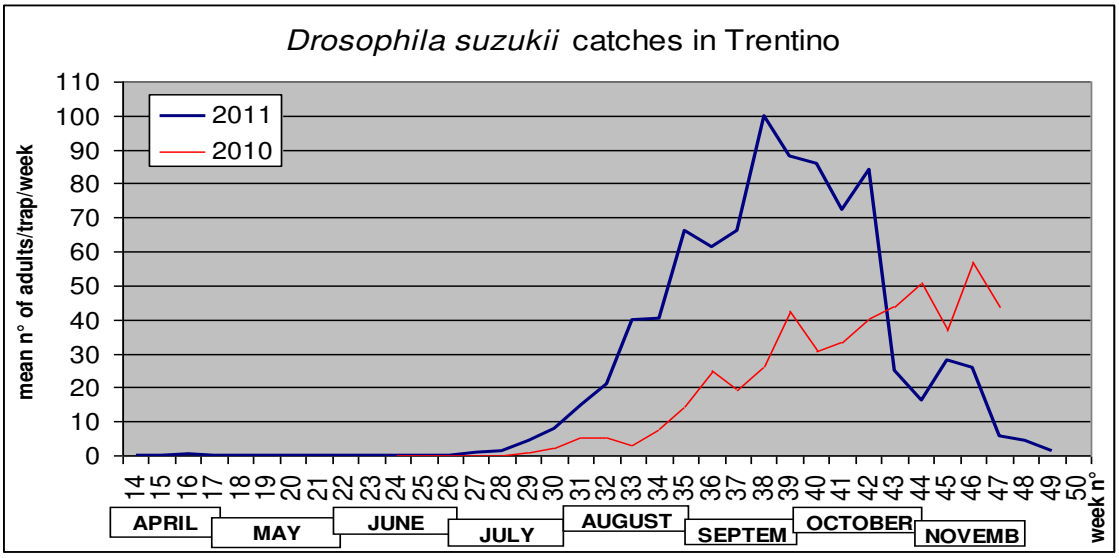

Figure 1: SWD flight recorded in Trentino in 2010 and 2011

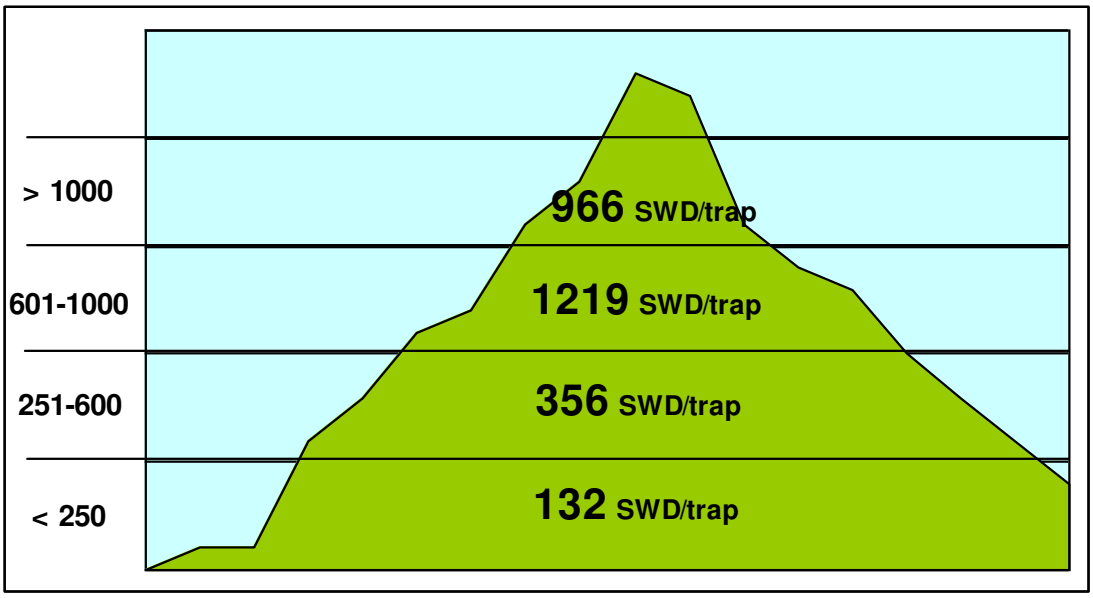

Figure 2: SWD adults catches according with the altitude of the trapping sites

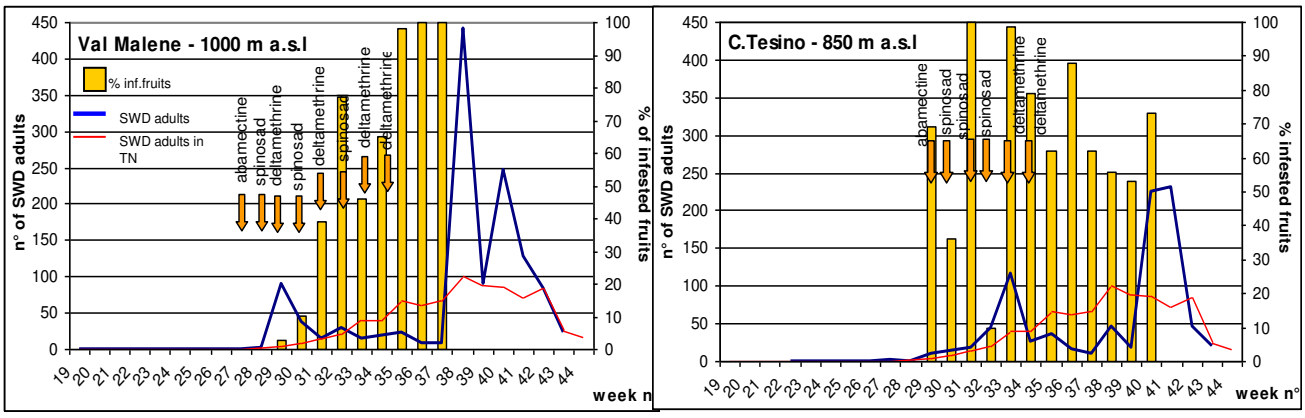

Figure 3 and 4: SWD flight and damage in a strawberry and a blackberry plantation

Table 2: infestation recorded on fruit samples in 2011

	PERCENTAGE OF FRUIT SAMPLES INFESTED BY SWD					
grape				25	71	
blackberry		0	82	100	100	75
blueberry		0	51	95	100	
raspberry		7	80	100	97	92
strawberry	0	0	50	70	71	53
cherry	3	11	46			
	May	**June**	**July**	**August**	**Septem.**	**October**

Table 3: results of mass trapping trial on highbush blueberry

week	SWD adults		% infested fruits		
	central trap	border traps	from central bushes	from border bushes	
21	*posit.*				
22-27	0				
28	0	*posit.*	0		**H**
29	0	11	0		**A**
30	0	84	0	7	**R**
31	1	156	0.8	5	**V**
32	1	111	0	2.2	**E**
33	0	1048	9	18	**S**
34	0	681	32	34	**T**
35	1	***end***	30		

Table 4 and 5: results of the trial with anti-insect nets on sweet cherry in Susà and V.Vattaro sites

week	SWD adults	% infested fruits				
		control plots		sprayed trees*	bagged trees	
		unsprayed branches	unsprayed trees			
19-26	0					
27	1	6	3.3	8	0	HARVEST
28	0	100	90	94	0	

**week 21 and 23: acetamiprid+spinosad - week 24 deltamethrine*

week	SWD adults	% infested fruits				
		control plots		sprayed trees*	bagged trees	
		unsprayed branches	unsprayed trees			
19-25	0					
26	0	nc	2	nc	nc	
27	0	3.04	2	0	nc	HARVEST
28	3	100	nc	70	0.4	

** week 25: deltamethrine - week 26: spinosad*

Table 6: results of the trial with anti-insect nets on highbush blueberry in Ronchi Valsugana site

week	SWD adults			% infested fruits				
	control	covered tunnel 1	covered tunnel 2	control	covered tunnel 1	covered tunnel 2	sprayed tunnel	
21-26	0	0	0					
27	1	0	0					
28	0	0	0	0	0	0	0	HARVEST
29	6	1	0	nc	nc	nc	nc	
30	2	1	0	6	0	0	0	
31	33	0	0	15	0	0	12	
32	30	0	0	27	0	0	1	
33	96	3	1	77	7.7	0	19	
34	46	19	16	88	end of harvest; net covering removed		nc	
35	120	removed		100			nc	

Discussion

The complexity of the environment, of the agro-ecosystems and the high concentration of small size soft fruits plantations in this small territory, represent an important additional force for *D.suzukii* in Trentino. The control of the pest was further complicated in 2011 by an extraordinary population development: also the insecticides showed to be an unreliable method in this situation. The alternative methods we tested this season demonstrated that can effectively contribute to the control of the pest. A multi-method approach seems to be the best way to manage *D.suzukii* infestations in a sustainable way in Trentino region.

Acknowledgements

We are grateful to all the advisors and colleagues of the Tecnology Transfer Centre at Edmund Mach Foundation, Sant'Orsola Soft Fruits Growers Association, the Regional Plant Protection Organization, the growers and to dr.Vaughn Walton (Oregon State University, Dept. of Horticulture) for his precious support and suggestions.

References

Hauser, M., Gaimari, S. & Damus, M. (2009): *Drosophila suzukii* new to North America. Fly times no. 43: 12-15.

Kanzawa, T. (1939). Studies on *Drosophila suzukii* Mats. Kofu, Yamanashi Agric. Exp. Sta.: 49 pp. Abstract in Review of Applied Entomology 29: 622.

Mitsui, H., Takahashi, K. H., & Kimura, M. T. (2006). Spatial distribution and clutch sizes of *Drosophila* species ovipositing on cherry fruits of different stages. Popul. Ecol. 48: 233-237.

Sasaki, M. & Sato, R. (1995). Bionomics of the cherry drosophila, *Drosophila suzukii.* Matsumura (Diptera: Drosophilidae) in Fukushima prefecture (Japan). Annual report of the Society of Plant Protection of North Japan 46: 164-172.

Sasaki, M. & Sato, R. (1996). Bionomics of *Drosophila pulcherella* Tan, Hus et Sheng (Diptera: Drosophilidae) in Fukushima prefecture (Japan). Tohuku Agric. Res. 49: 161-162.