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Kiwifruit pollination: the interaction between pollen quality, pollination systems and flowering stage

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Introduction

kiwifruit vine artificial pollination is nowadays a consolidate technique to increase kiwifruit quality and size. However pollination not always react the maximum efficiency (fig. 1): the results could change depending on the year, on the pollen harvesting system, on the pollination system. One of the causes could be the choice of the optimal floral stage of intervention in relation to the type of pollination. Many parameters were analyzed alone and in interaction in different environment in Italy and for many years**: pollen quality, pollination system, flowering stage**.
High quality pollen is basic for good results: germinability, germination energy, humidity were evaluated under different conditions of pollen harvesting, conservation at different temperatures and time of exposition at different temperatures, manipulation before and during pollination in different pollination systems (dry and liquid).
About pollination we evaluate the pollination efficiency of different pollination machineries and systems: dry pollination with pure pollen or diluted with licopodium, liquid pollination in water suspension, both by handing application or with mechanized tools (fig. 6).
The interaction of the pollination systems and the flowering stage were also evaluated. The aims was understand which is the best flowering stage in relation to the pollination system adopted: dry pollination or liquid pollination. At the time of pollination the flowers were labeled according to their flowering stage and the fruits size were measured in late season.

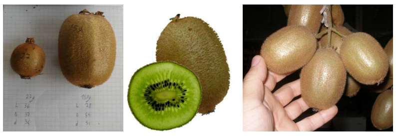
Figure 1 A. deliciosa cv Hayward fruits: extreme size of fruit due to the pollination efficiency (left), perfect pollination with many pollinated ovules (middle) and lateral flowers completely developed (right).


Figure 2 A. deliciosa cv Hayward in T-bar orchard in Verona with the male permanent leader in the middle. Despite this configuration , ideated by Tacconi Lorenzo in 1987, the pollination efficiency is low and is necessary harvest and distribute pollen to obtain fruits with good size.

	date	25 May 2009		22 May 2010	
	Pollen harvest system	Filter	Cyclon	Filter	Cyclon
Pollen	RH %	9-11	16-25	9-11	14-19
air	T°C max	21,1		29,9	
	T°C average	17,6		22,9	
	RH% average	85,6		63,9	
	RH% min.	55,3		25,9	

Figure 3 Effect of climatic conditions on the humidity of pollen collected by the two collecting systems.

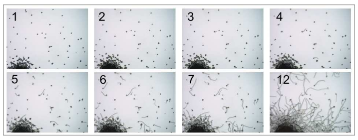

Figure 4 Pollen germination at 18 ° C for 15 hours: The number indicates the hours of germination..

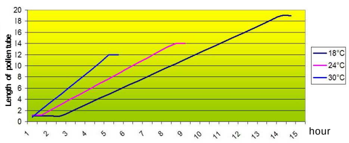

Figure 5 Performance of germination at three different temperatures in terms of elongation of the pollen tube. The length are reported as time of diameter (about 25 micron).

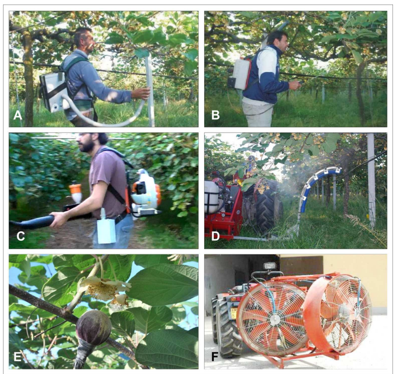

Figure 6 The machines used in the pollination-systems comparative test. A. 12V dry distributor pollen-licopodium (45% - 55%) mix Speedy (Dell'Agata, Forlì) (speed 5-7 h/ha); B. liquid distributor 12V diaphragm pump model Hozelok (4h/ha); C. blower dry distributor of pure pollen SoffiaPolline (Biotac, Verona)(1 h/ha);D. liquid distributor tractor machine (Gerbaudo, Cuneo), with fogger type nozzles (2 h/ha); E manual pollination ("pon-pon") (25 h/ha); F tractor fans Ventole (Romani, Verona) (0,5 h/ha).

Materials & Methods

All the experiments were performed on *A. deliciosa* cv Hayward in field condition with three repetitions per treatment, among 5 years (2009-2013).
Pollen harvest performances was evaluated using two different commercial machines: cyclon sistem (i.e. ApiraPollineMini2, fig. 2) and filter system (AspiraPollineTM, both by Biotac, Verona, Italy).
The **pollination-systems comparative test** (fig. 6) was conducted in Cuneo by CReSO (2009, 2010); the pollination was carried out with 90% of flowers at the stage of petal fall (with white pistils) with 600 g of pollen per hectare with a single step distribution. The experimental design was a randomized block in standard orchards (male:female rate 1:6) T-bar (Verona and Cuneo) and pergola (in Latina). The liquid distribution was 12 g/l of pollen in deionized water and 5ml/l of activator PollenAid (Kiwi Pollen, New Zealand) for a total of 50 l/ha of water suspension. The **role of the lycopodium** in dry pollination was evaluated comparing the Speedy dry pollination systems (Fig. 6A) and SoffiaPolline (fig. 6C) with and without licopodium added (in Verona, 2013).
In order to understand the **best flowering stage in relation to dry or liquid pollination** at the time of pollination the flowers were labeled according to their flowering stage (fig. 10) and the fruits size were manually measured in late season. The experiment was repeated in Cuneo (2010), Verona (2011-2013), and Latina (2011).

Results & Discussion

Pollen quality

- Pollen harvest system could influence the **pollen humidity** if the air relative humidity is high during the harvesting (fig. 3). The pollen humidity is crucial for long-term storage.
- **Pollen viability** are evaluated: germinability is more than 90% when pollen has an humidity lower than 10% and is stored at -20°C (up to 3 years). Pollen with high germinability could have low germination energy (length of germination tube) if there were stresses like exposure to temperature upper than 4°C for more than 1 hour during collecting, or storing with humidity upper than 12% (fig. 3) or if its germination occurs at temperature higher than 30°C (fig.4)

Pollination system

- In comparison with the free pollination and with the manual method of pon-pon (fig. 6E), the distribution **machine by liquid** (mod. Gerbaudo, fig. 6D) gave interesting results when used 2 days earlier than the **dry blower system** (mod. SoffiaPolline, fig. 6C) which gave the best results (fig. 7, 8).
- For these systems the **higher fruit size class** is 100-120 g (35%, also for "pon-pon") moreover the blower dry system reach the higher percentage in the biggest class size (15% 120-140 g, fig. 8).
- The low pollination rate observed using the pollen-licopodium mix Speedy machine (fig. 6A, 7) is due to the drying effect of the licopodium on pistills and don't depend to the machine: the addition of licopodium to the SoffiaPolline gave the same results (fig. 9).

Flowering stage

- About the flowering stage related to dry and wet pollination (fig. 10, 11), the best results were reached at **petals fall** in the case of blower **dry pollination system** (SoffiaPolline fig. 6C) (fig. 12), whereas for **liquid pollination system** (Gerbaudo, fig. 6D) the best results are at **full bloom-early petal fall** (fig. 13).
- Because the pistil exudate production increase with the flower maturity and is maximum at the petal fall stage (fig. 14), this could means that the **pistil exudate** allow the pollen attach if the pollen is dry, while if the pollen is conveyed with water the adhesion of the pollen grain or the tube's germination is not optimal.
- The bigger fruit size observed with dry pollination (fig. 8) could be related to **receptivity of the ovules** in the flower: the ovules maturation is not simultaneous and appear to be maximum at the petals fall stage that correspond to the stage just before pistils senescence (change from white to brown color).

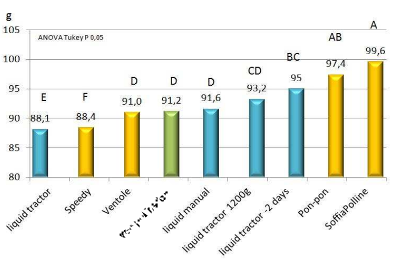

Figure 7 Average weight of the fruit. Different letters indicate statistically significant differences. Blue color is for liquid pollination systems, yellow color is for dry pollination system, green is natural pollination in the orchard.

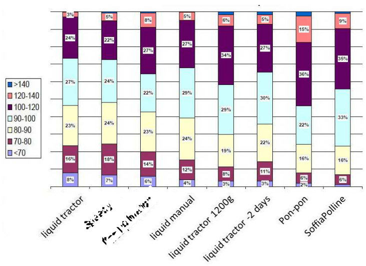

Figure 8 Distribution by class of fruit weight with relative percentages of the various classes in the various theses.

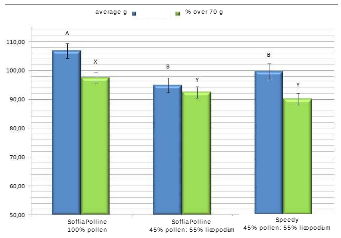

Figure 9 Average weight (grams, in blue) and percentage of marketable fruits (in green, it's the percentage of fruit for each size class over 70g). The free pollinated fruit average weight was 75g.

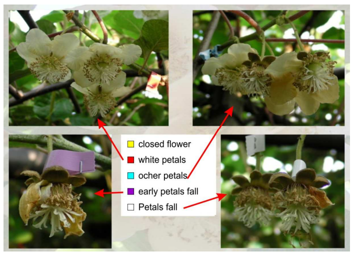

Figure 10 Floral stages marked with different colored ribbon at the pollination.

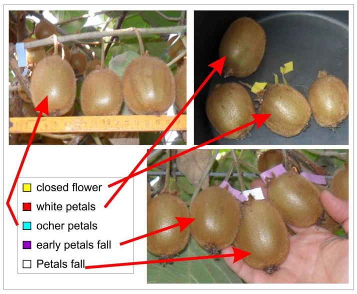

Figure 11 Fruits marked at the time of harvesting with the ribbon attached during pollination in order to go back the original flowering stage during pollination.

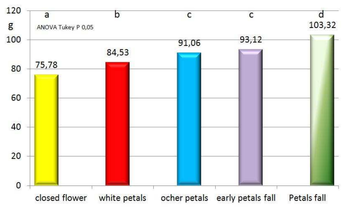

Figure 12 Average weights of the fruits pollinated by dry pollination system.

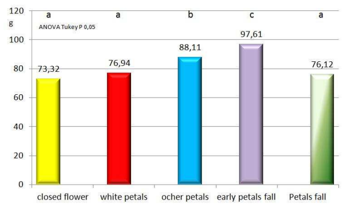

Figure 13 Average weights of the fruits pollinated by liquid pollination system.

Figure 14 Easy test for the evaluation of pistil exudate production: the maximum dry pollen receptivity is at early morning on flowers at the petal fall stage.

Conclusion

A good pollination is fundamental for the production of fruits well developed, with high caliber and high quality (fig. 1), with production increase up to 30% (fig. 7, 9, 13, 13). For high pollen quality the pollen must picked up from the collecting machine every 45 minutes (fig. 2) and stored at 4°C for no more than 7 days, then at -18°C for 3 years (max.), better if it has 10-12% of humidity. The dry pollination must be made with pure pollen at the end of flowering before the pistils became brown (petals fall stage in cv. Hayward) and the pistil exudate is maximum (fig. 12, 14), with environmental high humidity (early morning), usually in two steps in order to follow the flowering scalarity. Analogously the liquid pollination must be made not later than early petal fall stage (fig. 13).

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