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Dragon Fruit (*Hylocereus undatus*) Pollination in New Zealand: A Preliminary Report on Flower Visitors, Natural Pollen Deposition, and Artificial Pollination

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ABSTRACT

Dragon fruit (pitaya; *Hylocereus undatus*) is a promising, new high-value crop in New Zealand. The large nocturnal flowers open for one night and close early in the morning the following day over a 3- to 6-month long flowering period. In dragon fruit's native range, hawkmoths and bats are key nocturnal pollinators, and honey bees visit flowers during the day, but manual pollination is often required to achieve commercial yields. We assessed floral visitation, natural pollen deposition, and stigma receptivity for a self-incompatible dragon fruit variety. We also explored different pollen collection, processing, and storage techniques. A range of insects visited flowers during the day and night, and we recorded copious amounts of pollen on the stigma, but little pollen germination was observed; the reason for the lack of pollen germination is unclear. Stigma receptivity was highest at flower opening and gradually declined over time. Pollen could be efficiently collected with a commercially available, handheld keyboard vacuum. Pollen collected within 12 h of anthesis had the highest viability, and desiccating pollen for 30 min over silica gel or 12 h in a drying cabinet had no apparent negative effects on pollen viability, but longer desiccation periods did. Desiccated pollen stored at -20°C for 10 months had pollen viability similar to that of freshly collected pollen. Our results suggest that manual pollination of dragon fruit is required in New Zealand to overcome pollen deficits, particularly in self-incompatible varieties, and we outline methods to collect, process and store pollen to maintain viability to enable this.

1 | Introduction

Dragon fruit (pitaya; *Hylocereus undatus*) has been identified as a suitable high-value crop in the subtropics because of its precocious fruiting, longevity, tolerance to poor soil, and Crassulacean Acid Metabolism (CAM) pathway, which provides resistance to hot and droughty conditions (Muniz et al. 2019; Li et al. 2020). It is a new crop in Aotearoa-New Zealand, grown primarily in the subtropical Northland region (The Country 2023). Belonging to the Cactaceae family, it produces large, hermaphroditic, nocturnal flowers that each open for a single night over the flowering period, which spans three to 6 months, with several waves of flowers (Merten 2003). Flowers open at sunset and close a few hours after sunrise the next

morning, between 06:00 and 12:00 (Le Bellec 2004; Weiss et al. 1994; Muniz et al. 2019). Dragon fruit is capable of setting 100% of these flowers, but varieties of *Hylocereus* have differing degrees of self-compatibility, exhibiting anything from 0% to 100% fruit set with self-pollination (Le Bellec 2004; Moreira et al. 2022; Weiss et al. 1994; Pushpakumara et al. 2005). Whether owing to this incompatibility or to poor pollination, the first wave of flowers for the season often fails to produce fruit (Merten 2003). In their native range, key pollinators of dragon fruit are hawkmoths and bats (Valiente-Banuet et al. 2007). Studies in other countries have reported pollination deficits even with honey bee visitation (Weiss et al. 1994; Pushpakumara et al. 2005; Le Bellec 2004; Moreira et al. 2022),

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leading to the widespread artificial pollination of dragon fruit commercially (Wurz et al. 2021). Given the failure of natural pollination elsewhere, it is important to understand whether sufficient pollination is happening under current practices in New Zealand using managed honey bees and unmanaged pollinators.

Pollen deposition is highly correlated with fruit weight in dragon fruit (Weiss et al. 1994), with a higher pollen load producing larger fruit. Because *H. undatus* can have over 6000 seeds (Weiss et al. 1994; Valiente-Banuet et al. 2007) and in some varieties over 10,000 (Pushpakumara et al. 2005), it requires a correspondingly large quantity of pollen (Moreira et al. 2022), and although some varieties can be self-pollinated, fruit size is larger with cross-pollination (Weiss et al. 1994; Pushpakumara et al. 2005; Moreira et al. 2022). There are limited reports in the literature about collecting cross-pollen for artificial pollination using manual methods, such as shaking onto a plate (Pushpakumara et al. 2005), or removing anthers from flowers and applying them directly to receptive stigmas (Merten 2003). These methods have been sufficient for commercial production in Asia and South America, but present challenges for countries with higher labor costs (Merten 2003), necessitating the development of more cost-effective collection methods.

Pollen viability has been observed either to hold steady (Tran et al. 2015) or to decline over the course of flower opening (Le Bellec 2004), potentially affecting the ideal pollen collection time. Dragon fruit pollen is a trinucleate type, associated with difficulty in long-term storage (Metz et al. 2000), with some authors reporting complete loss in viability after 9 days (Macha et al. 2006; Li et al. 2022). For supplemental artificial pollination to be successful, particularly for the first wave of flowers each season, pollen storage over the course of several months is required. Cryopreservation of pollen in liquid nitrogen maintains high pollen viability (Anilkumar and Rajasekharan 2023); however, maintaining pollen in liquid nitrogen is unlikely to be economical for a large amount of collected pollen for use in artificial pollination. Further exploration of pollen preparation prior to storage at more typical cold-storage temperatures could assist in the preservation of pollen between flushes of bloom of different cultivars, and across seasons.

Identifying effective pollination methods is crucial for ensuring fruit production and is an important consideration enabling the success of the establishment of a crop in a new country. In this study, we aimed to 1) identify natural pollination rates and potential pollinators for dragon fruit in New Zealand, 2) determine the most effective time for pollination to occur, and 3) develop a new and suitable method for collecting and storing dragon fruit pollen while minimizing loss of viability.

2 | Materials and Methods

We examined pollination in a single cultivar of dragon fruit in a small research orchard near Kerikeri (Northland, Aotearoa New Zealand) for 1 week, 30 January–2 February 2024. Plants were grown along rows using a stake-and-wire trellis system and a planting distance of ≈ 1 m. Plant bases were covered with black plastic mulch, below which was a drip-irrigation system. The average humidity over this period was between 76% and 86%; the minimum and maximum temperature were 13.1°C and 31.5°C, respectively (Te Puna Waiora 2025). In previous trials, the cultivar was determined to be self-incompatible, with no fruit set occurring in the absence of cross-pollination (Satish Kumar, pers. comm.).

2.1 | Pollinator Surveys

Initially, pollinator surveys were planned to be transects of the orchard, but because of low flowering numbers (2–4 flowers opening per night), point counts at individual flowers were conducted instead. Point counts in other crops have resulted in a higher diversity of recorded pollinators than transects have (Hutchinson et al. 2022), increasing our chances of observing small-bodied and rare pollinators. Surveys were conducted under calm conditions, in the absence of strong wind and rain. At each survey point, the flower was observed for 5 min. Surveys were conducted in an ad hoc approach, to ensure surveys were performed at dawn (05:30–07:30; $n = 12$), in the morning (07:30–09:30; $n = 14$), midday (10:30–12:00; $n = 15$), and in the evening (20:30–22:30; $n = 16$). Where possible, a representative sample of each species observed on flowers was collected into a vial for later identification, but we were unable to collect every species observed.

Passive light trapping was conducted on 1 February 2024 with two Heath moth traps, which emit fluorescent light and automatically turn on at sunset ($\approx 20:30$) and turn off at sunrise ($\approx 06:30$) the following morning. Insects were collected the following morning, euthanized at -20°C and later pinned and stored for pollen analysis. Each large-bodied moth was swabbed with a 3 mm³ cube of gelatine-fuchsin (Kearns and Inouye 1993), by rubbing the gel on the antennae, eyes, mouthparts, legs, and the ventral side of the thorax and abdomen. The gel cubes were then melted on a glass slide and examined under 20 $\times$ magnification. All other insects were examined directly under a dissecting scope.

Dragon fruit pollen grains were counted and identified with the help of a reference sample. As they were substantially larger than the other pollen grains found in the samples, we were able to differentiate dragon fruit pollen from other pollen on insect bodies.

2.2 | Stigmatic Receptivity

Peroxidase activity on the stigmatic surface of dragon fruit flowers was assessed by applying a drop of hydrogen peroxide to one lobe of the stigmata (Dafni 1992; Moreira et al. 2022). The quantity of bubbles generated after 30 s was assessed by a single person for either 2 or 4 flowers (depending on flower availability) at different periods following flower opening: 0, 12, 24, 36, 48, 60, 72, and 84 h. We used a bin system, which is commonly used for this qualitative assessment (e.g. Makwana and Akarsh 2017), ranking activity as either – (no activity), + (weak activity), ++ (moderate activity), or +++ (strong activity), with strong activity being reflective of higher stigmatic receptivity than weak activity.

Previous literature has reported near-100% fruit set when hand-pollinated at 0 or 12 h, during the period of flower opening across cultivars (Muniz et al. 2019; Moreira et al. 2022), but less is known for *H. undatus* after this period—relevant for hand-pollination. To address this question, we hand-pollinated 10 flowers at 24 h post flower opening with pollen from a different cultivar that was >60% viable, to assess fruit set.

2.3 | Natural Pollen Deposition

Natural pollen deposition was assessed by marking 10 flowers that had opened the previous night and leaving them in situ

between 4 and 5 days, longer than the recorded time for pollen to germinate down the style and reach the ovary (Cho and Ding 2021). The pistils from 10 flowers were collected into 50 mL Falcon tubes containing 70% ethanol and stored in a refrigerator until processing. Stigmas were then processed using a modified procedure outlined by Martin (1959). They were removed from the ethanol and submerged in potassium hydroxide (4 g potassium hydroxide dissolved in 100 mL deionized water) for 24 h to soften the flesh. Stigmas were then removed from the potassium hydroxide and rinsed in a beaker of water. Owing to the large size of the pistil, the stigma and the first 1 cm of style were removed, placed on a glass microscope slide, stained with 0.1% aniline blue stain, and examined using fluorescence microscopy (10× magnification and using a Nikon UV-2A filter cube (330–380 nm) for the presence of pollen and pollen tube growth. Where pollen tubes were present in the first 1 cm of the style, the second 1 cm section of the style was removed and examined for pollen tubes. This process of examining the subsequent 1 cm of style was repeated until no pollen grains were detected, to assess if pollen tubes had grown to the ovary; however, no pollen tubes were detected beyond the second 1 cm section.

2.4 | Pollen Collection, Viability, and Storage

We trialed a number of methods and devices developed for the artificial pollination of kiwifruit for pollinating a self-incompatible dragon fruit cultivar, including harvesting anthers (Merten 2003) and direct vacuum collection (Broussard et al. 2023). Two vacuum models were evaluated: a modified vacuum unit designed for the collection of kiwifruit pollen, and an off-the-shelf handheld keyboard vacuum (120 W, with cyclone and 5.5 KPa suction). The quantity of pollen collected per flower as well as the ease of collection were both recorded.

We measured pollen viability using fluorescein diacetate (FDA) analysis, which is correlated with germination in dragon fruit (Weiss et al. 1994). Two samples were tested for each treatment condition. A total of 200 pollen grains were assessed in each sample for viability along longitudinal transects of the slide. We tested fresh pollen from several nights and tested the effect of prestorage desiccation on pollen viability. For desiccation, pollen was spread in a < 2 mm layer and kept either in a drying cabinet at 22°C for 12 or 24 h or placed in an open dish over silica gel for 0.5, 1, 2, 3, and 4 h. To assess long-term storage, pollen was vacuum-collected with the kiwifruit vacuum at flower opening, desiccated for 30 min over silica gel, and stored at 4°C, −20°C or −80°C for a period of 10 months.

2.5 | Statistical Analysis

All statistical analysis for the above experiments were done in R 4.3.3. Species accumulation curves for diurnal (41 samples, 56 insects) and nocturnal (16 samples, 5 insects) surveys of flower visitors were generated using the *specaccum()* function from R package “vegan”. Pollen viability measures were assessed using different methods depending on the relationship of the explanatory variable with pollen viability. The regression of pollen viability at different hours after anthesis (5 times × 2 replicates; $n = 10$) utilized a generalized additive model (GAMs) using *gam()* from R package “mgcv”. The relationship of pollen viability to

desiccation time (6 times × 2 replicates; $n = 12$) utilized a linear model using the base *lm()* function. In both cases, pollen viability was the explanatory variable, and time was the explanatory variable. Differences in pollen viability after storage under different temperature conditions (4 treatments × 4 replicates; $n = 16$) were assessed using a Kruskal–Wallis test via the *kruskal()* function from R package “agricolae”, and pairwise comparisons between treatments were made using a Wilcoxon rank sum test using the same function.

3 | Results and Discussion

During the observation period, flowers began to open between 19:00 and 20:30 h and closed between 8:00 and 12:00 h the following morning. As flower closing was often delayed until 10:00–12:00, dragon fruit flowers in New Zealand experience a larger number of hours open during daylight than observations from other regions (Le Bellec 2004; Weiss et al. 1994; Muniz et al. 2019), potentially increasing the chances of diurnal pollination.

3.1 | Pollinator Surveys

We observed 56 diurnal insect visitations (0.28/minute) and five nocturnal insect visitations (0.06/minute). Diurnal surveys had a higher rate of species discovery than nocturnal surveys (Figure 1), and the sampling effort was probably sufficient to

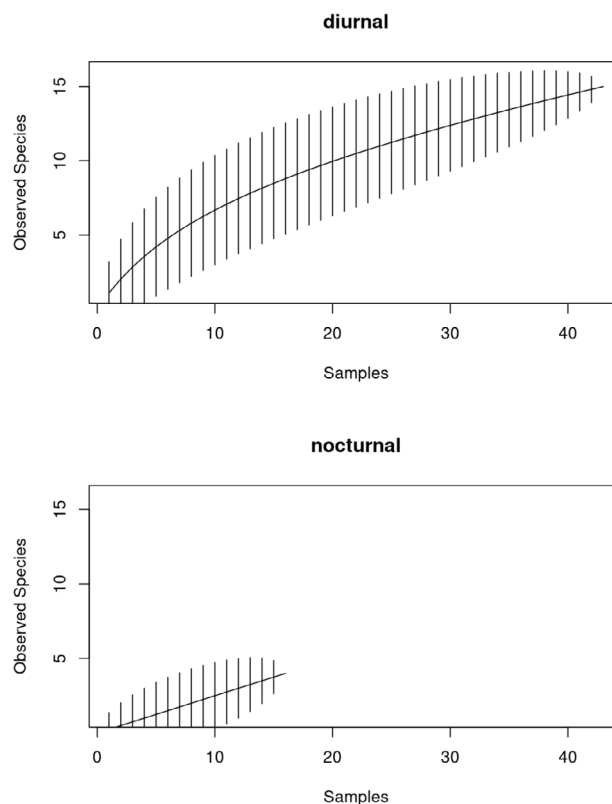


FIGURE 1 | Rarefaction curves for 5-min diurnal and nocturnal insect surveys of dragon fruit (*Hylocereus undatus*) floral visitors near Kerikeri, New Zealand, in 2024. Vertical lines represent the range of species at each number of samples across 100 randomisations, and curves represent the mean number of species.

discover most diurnal species, but not nocturnal species, so future observations are likely to identify additional nocturnal flower visitors. The most frequent diurnal visitors were several species of minute flies that could not be identified on the wing, followed by *Melanostoma fasciatum* (Syrphidae; Figure 2) and *Apis mellifera* (Table 1). The most frequent nocturnal visitors were also minute flies, as well as scarab beetles, an ant, and a moth (Table 1).

Although honey bee colonies were located in the orchard, they did not reliably forage on dragon fruit flowers until after 10:00—and flowers did not always stay open that late into the morning. *Melanostoma fasciatum* frequently visited the flowers, and numerous individuals were observed touching both male and female reproductive parts, despite their small size (Figure 2); however, given the self-incompatibility of this cultivar, it is unlikely that they are contributing substantially to pollination.

A total of 103 nocturnal insects were caught in Heath moth traps, and although not one of these was observed to carry dragon fruit pollen, they did carry pollen from a range of other plant species. The majority of trapped insects were moths (87%), followed by beetles in the family Elateridae (7%), and the remainder included a handful of Diptera, Hemiptera, Hymenoptera, Neuroptera, Orthoptera, and Trichoptera (Table 1). The most common moths were *Orocrambus flexuosellus* (Crambidae) and *Epyaxa rosearia* (Geometridae), with a range of *Ichneutica* species and *Agrotis ipsilon* (both Noctuidae) being present but less common. Each of these moth species is thought to be a pollinator for other plant species in some capacity (Primack 1983; Buxton et al. 2021; Buxton et al. 2024). Given the low flowering intensity at the time of trapping, future work may be necessary to better understand if these or other nocturnal insects visit dragon fruit flowers.

3.2 | Stigmatic Receptivity

We found a gradual decline in peroxidase activity on the stigmatic surface over the 0, 12, 24, 36, 48, 60, 72, and 84 h post-flower-opening sampling period (Table 2). At opening, peroxidase activity was highest, which then decreased to no activity at 72 and 84 h (Figure 3). Stigmatic receptivity was highest from flower opening until the following morning (12 h) and decreased

over time, and the decrease over time is in agreement with peroxidase tests from Brazil, which found the stigma viable until at least floral closure (Muniz et al. 2019; Moreira et al. 2022). While Weiss et al. (1994) reported fruit set after 24 or more hours for other *Hylocereus* species, we found that none of the 10 flowers pollinated with viable pollen 24 h after flower opening set fruit, indicating that pollination, whether artificial or natural, must occur within the first 12 h of flower opening for the clone of *Hylocereus undatus* we assessed.

3.3 | Natural Pollen Deposition

We assessed natural pollen deposition and pollen tube growth in 10 dragon fruit flowers. We found that each of the 10 stigmas had copious amounts of pollen deposited on the stigmatic surface but in only four of the 10 samples a very small number of pollen tubes were observed (1, 5, 8, and 50 tubes) (Figure 4). Most of the pollen on the stigma failed to germinate or appeared to have quickly aborted, but the reason for this remains unclear. Manual hand-pollinations conducted in a different trial at the same time were successful, indicating that environmental conditions were favorable for pollen tube growth and fertilization to occur. It is also unclear whether this pollen came from flowers of a different cultivar that were flowering at the same time, or if the pollen was self-deposited; however, even in self-incompatible varieties, any self-deposited pollen grains are still expected to germinate, and some amount of pollen tube growth should be observed before tubes are aborted (Li et al. 2022). The reason for the lack of pollen tube growth on our 10 focal flowers remains unknown and an area for future research.

In addition to the pollen tube data, we observed no fruit set for any of the ten focal flowers, nor the 50+ flowers of the same cultivar that opened in the 3 days prior to the trial period. Despite our relatively small sample size, these results suggest that natural pollination by insects is currently insufficient for self-incompatible dragon fruit production in New Zealand and that artificial pollination using pollen from a compatible cultivar is required. Work is required to determine if current pollination conditions are suitable for fruit production in self-compatible varieties or if pollination services need to be boosted. For self-incompatible varieties, artificial pollination methods are probably required for fruit production, an approach that is used internationally



FIGURE 2 | The hover fly *Melanostoma fasciatum* (Syrphidae) was the most frequent identifiable visitor to dragon fruit (*Hylocereus undatus*) flowers in New Zealand. Despite their small size, individuals were frequently seen moving between the anthers and stigma within a flower.

TABLE 1 | List of floral visitors observed on dragon fruit (*Hylocereus undatus*) flowers near Kerikeri, New Zealand, in 2024, and whether dragon fruit pollen was observed on the body of collected insect specimens.

Diurnal/ nocturnal	Order	Family	Species	Number observed per 10 min ^a	Dragon fruit pollen ^b
Diurnal	Hymenoptera	Apidae	<i>Apis mellifera</i>	0.33	—
		Apidae	<i>Bombus</i> sp.	0.09	—
		Halictidae	<i>Lasioglossum</i> sp.	0.05	—
		Ichneumonidae	<i>Ctenochares bicolorus</i>	0.09	no
		Formicidae	Unknown ant	0.23	—
	Coleoptera	Nitidulidae		0.05	yes
	Diptera	Sarcophagidae		0.14	no
		Syrphidae	<i>Melanostoma fasciatum</i>	0.47	yes
		Syrphidae	<i>Eristalis tenax</i>	0.05	—
		Unknown	Unknown Microdiptera spp.	0.84	yes/no
	Hemiptera	Ricaniidae	<i>Scolypopa australis</i>	0.05	yes
	Mantodea	Miromantidae	<i>Miomantis caffra</i>	0.05	no
	Lepidoptera	Nymphalidae	<i>Danaus plexippus</i>	0.05	—
		Pieridae	<i>Pieris rapae</i>	0.09	—
	Araneae	Unknown	Unknown spider	0.05	—
Nocturnal	Hymenoptera	Formicidae		0.13	—
	Coleoptera	Nitidulidae		0.13	yes
		Unknown		—	yes
	Diptera	Unknown Microdiptera	Unknown Microdiptera spp.	0.25	yes/no
	Lepidoptera	Unknown	Unknown moth	0.125	—

^aThe mean number of insects observed across all diurnal or nocturnal transects, scaled to a 10 min window.

^bPollen presence was assessed only if a specimen of the species was captured; if no specimens were available, the value was marked “—”.

TABLE 2 | Results of *Hylocereus undatus* stigmatic receptivity from the peroxidase activity assay. We use a bin classing system ranking peroxidase activity as either – (no activity), + (weak activity), ++ (moderate activity), or +++ (strong activity), with strong activity being reflective of higher stigmatic receptivity than weak activity. The shaded row in the table indicates the 24 h after the flower opening time period where fruit set did not occur, based on any of the 10 flowers we pollinated.

Time since opening (hours)	Peroxidase activity	
	Flower 1	Flower 2
0	+++	+++
12	++	+++
24	++	++
36	+	++
48	+	+
60	–	+
72	–	–
84	–	–

(Merten 2003; Li et al. 2020). Increasing the intermingling of different cultivars so that pollinators are more likely to transfer suitable pollen is also worth exploring.

3.4 | Pollen Collection, Viability, and Storage

Pollen collection by harvesting anthers from one half of the flower and allowing them to dehisce at room temperature yielded a smaller quantity of pollen per flower (0.0014 g) than vacuuming (0.1390 g) using a device designed for kiwifruit pollination trials for the other half of the same flower. All anthers were dehiscd on flower opening, and during anther removal, a substantial quantity of pollen was lost to the environment. Vacuuming with a keyboard vacuum yielded more than double the amount of pollen per flower than the device built for kiwifruit; it was also by far the fastest pollen collection method assessed, with collection taking less than 10 s per flower.

Fresh pollen collected at the time of flower opening was 65.8% (range 60.0%–72.6%). Pollen remaining in anthers gradually lost viability in the 2 days following anthesis (Figure 5).

Desiccation of pollen in a drying cabinet for 12 h appeared to have no effect on pollen viability if pollen was collected within 12 h of anthesis, with final viabilities in excess of 60%. Older pollen, collected 24 h after flower opening, and subjected to the same procedure, resulted in final viabilities of less than 20%.

When drying pollen over silica gel, there was a strong, negative correlation with pollen viability for drying times exceeding 1 h ($p > 0.001$; adjusted $R^2 = 0.901$; Figure 6), although drying for 30 min appeared to have no negative effect.

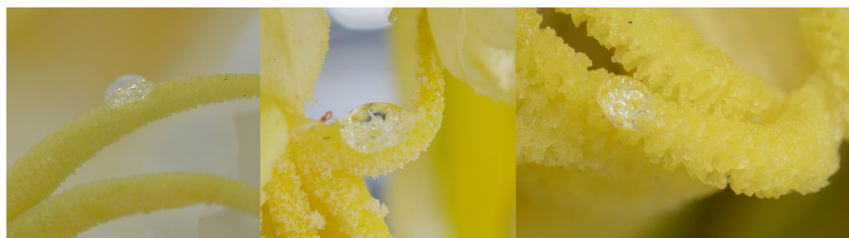


FIGURE 3 | Examples of peroxidase activity on dragon fruit (*Hylocereus undatus*) stigma. Based on our visual observations of a “bubbling” reaction, the image on the left was scored as strong activity (+++), the middle scored as weak activity (+), and the image on the right was scored as no activity (–).

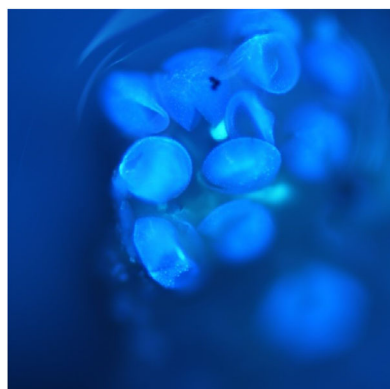


FIGURE 4 | Dragon fruit (*Hylocereus undatus*) pollen grains stained with a 1% aniline blue dye naturally deposited on a dragon fruit stigma observed at 10× magnification using a Nikon UV-2A filter cube (330–380 nm excitation wavelength). The light blue-green, fluorescent objects emerging from the dark blue pollen grains are pollen tubes that began growing but were quickly aborted.

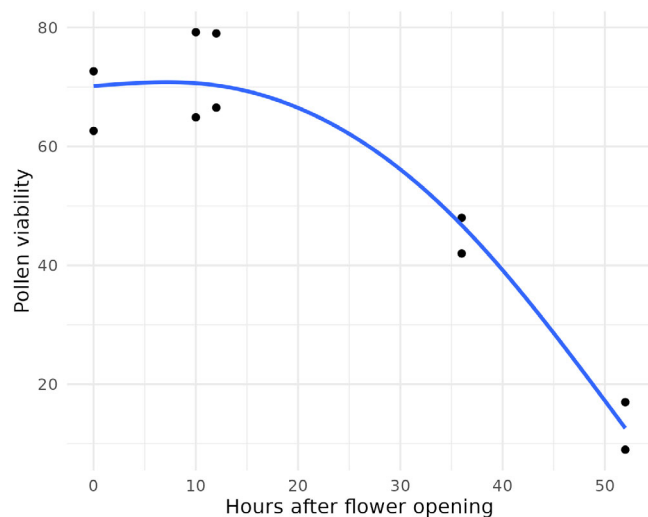


FIGURE 5 | Viability of pollen (given as a percentage) collected from dragon fruit (*Hylocereus undatus*) flowers 0, 10, 12, 36, and 52 h following anthesis. The line represents the best-fit generalized additive model (GAM) with $k = 1$ (adjusted $R^2 = 0.927$).

After 10 months, pollen stored at -20°C maintained viability similar to that of fresh pollen, while pollen stored at 4°C was almost entirely inviable, and the viability of pollen stored at -80°C was around 20% (Figure 7). A similar result, where very

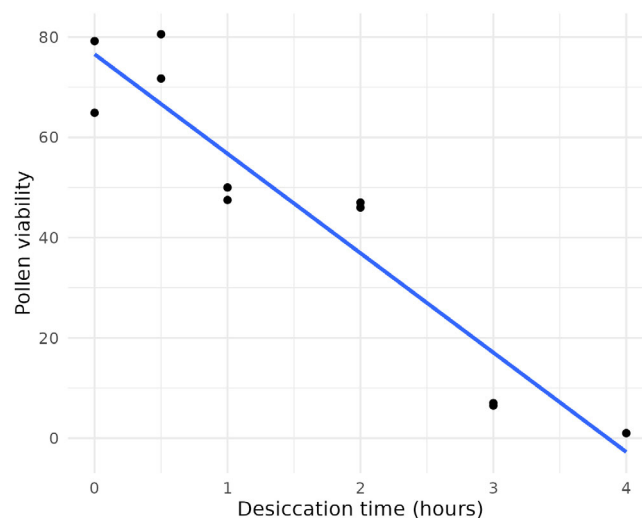


FIGURE 6 | Effect of desiccation time (hours) over silica gel on dragon fruit (*Hylocereus undatus*) pollen viability (given as a percentage). The line represents the best-fit linear model for the data series (adjusted $R^2 = 0.901$).

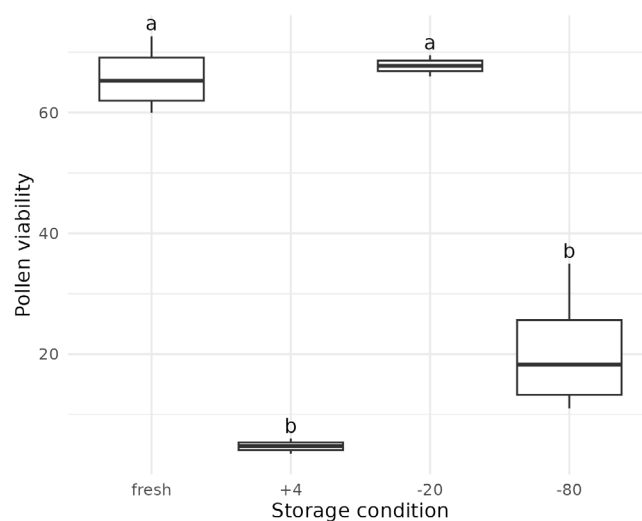


FIGURE 7 | Viability of dragon fruit (*Hylocereus undatus*) pollen (given as a percentage) after being desiccated in a < 2 mm layer for 30 min over silica gel for both fresh pollen and pollen stored for 10 months at 4°C , -20°C , and -80°C . Boxes represent the middle 50% of data, and lines within them the median. Letters represent significant differences between groups as determined by a Kruskal–Wallis test with Bonferroni correction ($p = 0.026$).

low temperatures resulted in worse viability outcomes than pollen stored at -20°C , was found by Abreu and Oliveira (2004) for kiwifruit pollen.

Additionally, pollen that was not fully dried prior to storage had worse outcomes in storage, with pollen stored at -20°C after ten months having less than 15% viability. The trinucleate pollen of dragon fruit, similar to other trinucleate pollen (Gill 2014), may be particularly sensitive to moisture content for long-term storage, with conditions both too dry (over-desiccation with silica gel, storage at -80°C) and too moist (pollen stored without an appropriate drying step) negatively affecting storability. However, we have determined that if pollen can be desiccated correctly over either silica gel or in a drying cabinet, and stored at -20°C , it maintains sufficient viability to be applied to the first wave of flowers in the following flowering season, and pollen stored in this way has successfully been used to achieve fruit set (Satish Kumar, pers. comm.).

4 | Conclusions and Recommendations

Dragon fruit appears to have a longer period of flower opening during the day in New Zealand than in other global regions producing the crop. Despite this longer flowering window, no fruit set across 50 flowers co-flowering in a flush, and insect visitation and deposition of compatible pollen was limited and is likely to be insufficient for adequate pollination of self-incompatible varieties. To address this, we explored a number of approaches for artificial pollen collection and storage in the New Zealand context. Pollen should be collected within the first 12 h of flower opening for highest viability, and dried over silica gel for 30 min, or in a single layer in a drying cabinet for 12 h at 22°C , prior to storage at -20°C . Pollen that is processed like this should maintain a degree of viability similar to that of freshly collected pollen, even after 10 months of storage. For optimal chances of fruit set for self-incompatible varieties, flowers should be artificially pollinated within 12 h of flower opening. Future work is required to determine if other practices, such as increased interplanting of different cultivars and strategies to increase pollinator activity, are suitable solutions for enhancing pollination for self-incompatible cultivars.

Author Contributions

M.N.B and M.A.B conceptualized the experiments and acquired funding; M.N.B. and M.A.B. developed the methodology; M.A.B. and L.M. conducted field investigations; M.N.B. and M.A.B. conducted lab investigations; M.A.B. conducted the formal analysis; M.N.B. and M.A.B. wrote the manuscript, and all authors approved the final version.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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