2024年【科學探究競賽-這樣教我就懂】

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題目名稱:Seed Dispersal Experiment by Wind

一、摘要

In this project, we explore how the wing length of a wind dispersal seed affects how far it can travel. The purpose is to learn more about flying seeds. First, I designed five different paper seeds with varying lengths of wings. Then, I dropped them around four meters high to see how long they would stay in the air. The result is that the longer the wind was, the longer it would remain in the air. However, I think my data is not relatively stable because, during the experiment, I observed that the two seeds were not as balanced as the others. In conclusion, I discovered that the longer the wing is, the further it can travel.

二、探究題目與動機

Seed dispersal plays a big role in spreading a plant's offspring. While wind dispersal is one of the most interesting and effective ways of seed dispersal, what is its purpose? What are the ways of seed dispersal? And what are some advantages and disadvantages of each different way of seed dispersal?

Seed dispersal is the spread of seeds far away from their parent plants to new locations, in order to increase the survival and successful germination of their offspring by decreasing competition with the offspring's parent plant. Besides that, it also brings multiple advantages to plant species. For example, seed dispersal allows plants to colonize new areas that have favorable environments for plant species. By reaching these new areas it gives plants a chance to inhabit these lands, therefore expanding the range of the plant species. It also promotes genetic diversity when seeds travel over greater distances there's a chance that they will mix with seeds from other plant species, resulting in more genetic variation and more genetic variation allows the species to adapt to climate changes, the ability to resist diseases, and survive in different environments.

There are a few ways of seed dispersal: animal dispersal, water dispersal, explosion dispersal and wind dispersal. Animal dispersal disperses by attracting animals to eat seeds and eventually they will come out of their bodies in a new location and germinate where it lands. Some of the advantages of this process is that animals, like birds, can transport it to a specific location increasing the chances of germination in a suitable site. Also, the animal would deposit seeds with fecal material containing rich nutrients, benefitting the growth of the seed. On the other hand, animal dispersal has limited distance since animals only live in their habitat. The seed would only grow in that animal's area leading to less potential for long-range dispersal.

Water Dispersal is the dispersal of seeds through water. Water-dispersed seeds have structures or adaptations that allow them to float on water. Some of them have air pockets or spongy tissue characteristics that increase buoyancy, and some have fibrous or hairy structures that also enhance buoyancy and surface areas that were exposed to air or water, which help them float and travel on water more effectively. Water dispersal can carry the seed to new areas, so the seed can colonize new places, but water dispersal is only effective in aquatic and riparian habitat zones which also limit its access to other terrestrial ecosystems.

Explosion dispersal is a method of dispersal where there is shooting of the seed out of the pod. Plants that use this method of dispersal have elastic tissues and tension cells, or in a mechanical way stressed tissues. These are structures that store energy during seed development. Eventually, they would reach a threshold, which would release all the energy ejecting the seed into the air at high speed. Explosion dispersal can reduce the chances of their offspring competing for resources and survival with closely related plant species. Since the seed is dispersed by shooting the seed out of the pod, there’s a chance that it could collide with hard objects that would result in damaging the seed leading to unsuccessful germination.

Finally, wind dispersal is the dispersal of seeds through wind. Seeds coming from wind dispersal plants have wing-like structures that allow them to travel in air for a long distance. I think wind dispersal is the best way of seed dispersal, because unlike animal dispersal its dispersal area won’t be limited by the animal's habitat. It also won’t be limited by geographic factors like water dispersal, where the seed can only follow the body of the water's path. Likewise, while wind dispersal is similar to explosion dispersal, because in both ways the seeds travel by air, wind dispersal is safer. They both have a chance of getting hit by hard objects, but since they don't travel at high speed, when wind dispersal seeds get hit by hard objects they won’t do as much damage and still have a successful chance of germination.

三、探究目的與假設

I want to study more about seed dispersal via wind. In this paper I will talk about how the length of the seed’s wing affects how far the seed can travel.When I see the seed flying in the sky, I ask myself how the seed can fly such a long distance. In conclusion, I hypothesize that the bigger the wings are, the further the seed can travel, because when the wings are bigger more air particles will hit the wings allowing them to stay up in the air longer.

四、探究方法與驗證步驟

To test whether my hypothesis is true or not I have worked on an experiment. First of all I created 5 paper seeds with different wing sizes, seed A has the smallest wing and seed E has the biggest. The way in which I made my seed is demonstrated below:

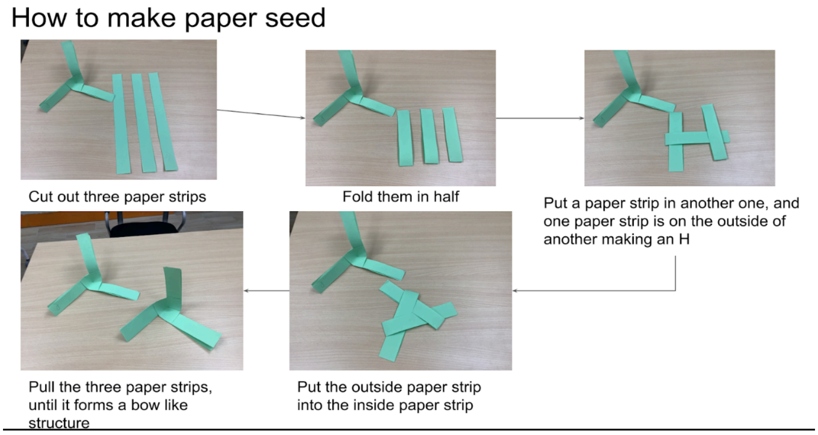

Fig 1 (It's a Shorea)

The paper seed I made is like a Shorea seed shown in Fig 1; it has more than one wing, and the seed is in the middle of it, meaning that the center is heavier. Similarly, my seed has three wings and since the paper strips were all stacked together in the middle, the center would be heavier. The center is very important for a flying seed, because the center will affect the seed's stability and balance. If you want the seed to be stable, the center weight must be located at a position that would ensure the object would stay at equilibrium. If the center of mass isn't at the right position it would cause the paper seed to become unstable. That is why I created this kind of paper seed, because the size and weight of the center is easier to control with this method.

五、結論與生活應用

After making these seeds, I dropped them from around 5 meters high and recorded how long it took for the seed to reach the ground. When I experimented I repeated this step 7 times, because I wanted my data to be more reliable, and seven times was just enough. When I did my experiment, the air humidity was very high, so I don't think it was the best condition to do it in, since my paper seed would get wet and become heavier; if the weather was drier, the result would have been better. The result is shown below:

Fig 2 (Graph about the average time it takes for the seed to reach the ground from the smallest to the biggest) (self-made)

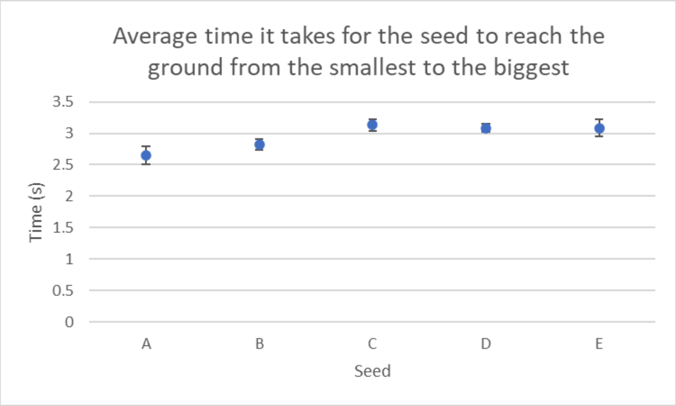

Table 1 (Data recorded) (self-made)

	Time it takes to fall (s)	A	B	C	D	E
	Attempt 1	2.69	2.91	3.47	3.04	3.24
	Attempt 2	2.85	2.85	3.16	3.3	3.48
	Attempt 3	2.93	2.61	3.02	3	2.78
	Attempt 4	2.7	2.71	2.86	3.21	2.71
	Attempt 5	2.97	2.95	3.23	2.95	2.88
	Attempt 6	2.24	3.07	3.15	3.07	3.17
	Attempt	2.19	2.61	3.02	3.01	3.33
	Average	2.65	2.82	3.13	3.08	3.08
	best estimate	2.65	2.82	3.13	3.08	3.08
minimum scale (cm)	Standard deviation	0.317423	0.177281	0.193218	0.125925	0.295232
0.1	Type A uncertainty	0.141956	0.079282	0.08641	0.056315	0.132032
	Type B Uncertainty	0.028868	0.028868	0.028868	0.028868	0.028868
	absolute uncertainty	0.144861	0.084374	0.091104	0.063283	0.135151
	Reserve two digits are valid	0.15	0.09	0.09	0.06	0.14

	Result	(2.65±0.15)	(2.82±0.09)	(3.13±0.09)	(3.08±0.06)	(3.08±0.14)
	Standard error	0.239949	0.134012	0.146059	0.09519	0.223174

Table 1 shows the data I've recorded and the average, best estimate, standard deviation, Type A Uncertainty, Type B Uncertainty, absolute uncertainty, Reserve two digits are valid, Result, and Standard errors. In Fig 2, the blue dots represent the average time, and the perpendicular line passing through the blue dots is a standard error. As you can see, the seed with the smallest wings (seed A) fell to the ground the fastest. As the wings got bigger the other seeds fell slower, and you can see from seed C to seed E that the time it took to reach the ground doesn't change much further. This absence of change is because when the length of the wings reaches a certain point, the wing won't decrease the speed no matter how big it gets. Seed C stays in the air longer because its wings are bigger than seeds A and B; having bigger wings allows more air particles to hit it and helps the seed to stay in the air longer. Clearly, seed A drops faster than the others; this has a direct connection to seed C; seed C can fly longer because it has bigger wings; oppositely, if the seed has shorter wings, fewer air particles would hit it, making it fall faster. This proves that my hypothesis is correct.

Fig 3 (Graph made by Tracker) (self-made)

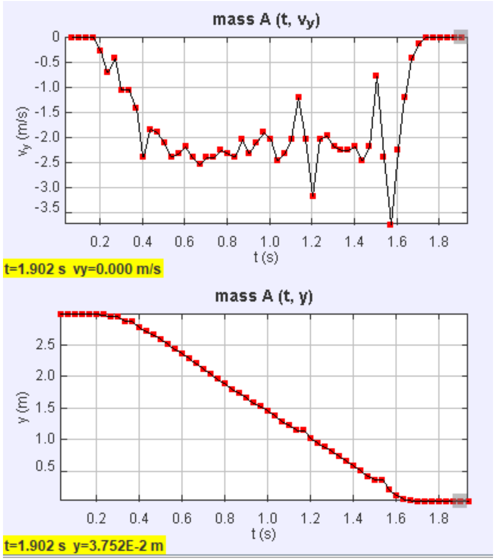

Fig 3 shows two graphs made by Tracker. In the first graph, the longitude shows the velocity of the seed, and the latitude shows the time it takes to fall to the ground. At first, nothing was changing, because I was holding it, when I let it go it fell at high speed. This period is called Free Fall, when the seed isn't affected by anything but gravity. Eventually, it would start to spin, slicing through the air and lifting the seed up which slowed down its descent. Then, it would enter the Slow Fly period, where the speed of how fast the seed spins enters a maximum point, and resistance would start to increase, decreasing the lifting force. Finally, it would enter the Terminal velocity period, which is when the lifting force, resistance force, and gravity reach equilibrium. The graph in the lower part of Fig 3 shows how close the seed is to the ground.

The results came out just as I had expected, the bigger the wings were, the longer it took to fall to the ground as shown in Fig 2, and when it took longer to reach the ground, it could travel further away from the parent plant. The results match my hypothesis. In my experiment there were few limitations or constraints, first of all I need to make sure every seed falls from the same height, because if some seeds fall from a higher place and some of them fall from a lower place, it would create a difference. Seeds from higher places would take a longer time to reach the ground, while seeds at lower places would take less time to reach the ground.

Another limitation of the experiment is the center weight of the seeds. As I've mentioned before, the center maintains the seed's stability and balance, so I need to ensure a seed's center has the same weight and size. That is also why I designed my paper seed using the method shown in page three, it's easier to control the size and weight of the center.

My third limitation is that I have to drop each seed the way I drop my first seed, there are no differences between how I drop each of them. In conclusion, I think my data is not quite stable because during the experiment I observed that seed D and E's fall, they are not as stable as the others. Although through Fig 2, the standard error is small, I think this is something that can't be observed through data analysis. They were unstable. It has something to do with its center, since the center plays a big role in a flying object's stability and balance, if the center was adjusted to be heavier or bigger, I think they can fly better then the other seeds.

In this study, I discovered that the longer the wing is, the further it can travel. I have used Excel to analyze all sorts of data, such as average, Type A Uncertainty, standard deviation, standard error, etc. Then we used Tracker, an analyzation software, to track down the speed of the seed. I find that if the length of the wings are bigger, the seed can fly further and also the center is very important to the seed. For further research, we can analyze what are the other factors that affect how far a seed can travel to figure out the processes and consequences of wind dispersed seeds.

參考資料

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