

27 August 2002
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Dear Sir

Comparison of aerodynamic performance of frost fans

I have compared the aerodynamic performance of two different frost fans. One of the fans had two blades and the other had four blades.

Both of the fans were supplied and installed by Hawkes Bay Wind Machines Ltd and were tested on the Hawkes Bay Wind Machines' test rig in Hastings. The test rig keeps the fan fixed in one direction (whereas in an orchard the fan rotates about its vertical axis in about 5 minutes). The hub height of the test rig mast is 10.5m and the shaft is tilted to blow downwards at an angle of 6 degrees from horizontal. The same engine and gearboxes were used in both tests.

Both fans were approximately 5m in diameter (5290mm for the two blade fan, 5 for the four blade fan). You stated that the standard operating engine speeds for the two different fans are:

- Two Blade Fan 2,150 revs per minute
- Four Blade Fan 1,800 revs per minute.

I measured the air speed from each fan at an array of 45 different locations. These were:

- all 10m from the centre of the test rig mast
- at three heights: 9.5m, 10.7m, and 11.
- at fifteen lateral positions, from 3.5m left of the centreline (when viewed looking towards the fan) to 3.5m right of the centreline, at 0.5m intervals.

The 9.5m height is approximately level with the centre of the jet at 10m distance.

I measured air speeds using cup anemometers, recording and averaging the air speed over a period of 100 seconds at each location. I measured the engine shaft speed for each test using a hand held optical tachometer.

Prior to each test, we attempted to adjust the engine throttle to achieve the standard operating engine speed as closely as possible. With the hand controlled throttle, it was not possible to achieve the exact desired engine speed, and consequently the two blade fan was tested at 2140rpm, rather than the standard speed of 2150rpm. This difference is negligible.

I tested the two blade fan on the evening of 31 July 2002. I tested the four blade fan on the morning of 1 August 2002. Weather conditions were therefore quite similar for both tests.

Date	Wind	Air Temperature	Air Pressure
31 July 2002	Still	11.5°C	1028mB
1 August 2002	Still	8.3°C	1032mB

Results

Measured air speeds for the two fans are shown in Table 1 and Table 2.

Table I Measured Airspeeds for Two Blade Fan

Engine RPM	Height	11.9m	10.7m	9.5m
		Airspeed (m/s)	Airspeed (m/s)	Airspeed (m/s)
2140	Left 3.5m	1.5	1.6	0.5
2140	Left 3.0m	1.3	1.9	1.0
2140	Left 2.5m	1.4	2.7	2.8
2140	Left 2.0m	2.8	5.5	7.5
2140	Left	4.5	10.3	12.2
2140	Left 1.0m	6.6	13.9	16.2
2140	Left 0.5m	9.3	17.5	17.2
2140	Centre	10.7	19.0	15.5
2140	Right 0.5m	11.4	18.8	13.3
2140	Right	8.3	18.4	17.9
2140	Right 1.5m	5.7	11.3	15.2
2140	Right 2.0m	1.7	4.1	6.5
2140	Right 2.5m	1.6	3.5	5.3
2140	Right 3.0m	1.0	0.5	2.1
2140	Right 3.5m	0.3	0.3	0.0

Table 2: Measured Airspeeds for Four Blade Fan

Engine RPM	Height	11.9m	10.7m	9.5m
		Airspeed (m/s)	Airspeed (m/s)	Airspeed (m/s)
1800	Left 3.5m	2.0	4.9	4.1
1800	Left 3.0m	3.2	9.2	9.9
1800	Left 2.5m	5.3	12.6	10.3
1800	Left 2.0m	6	17.6	16.4
1800	Left	10.8	19.1	16
1800	Left 0.5m	12.3	16.3	12.4
1800	Centre	13.5	17.0	12.7
1800	Right 0.5m	13.1	18.3	15.7
1800	Right 1.0m	11.1	15.8	17.5
1800	Right 1.5m	7.7	10.6	12.8
1800	Right 2.0m	2.4	5.5	6.2
1800	Right 2.5m	2.2	4.8	7.0
1800	Right 3.0m	1.3	1.5	2.3
1800	Right 3.5m	0.4	0.5	1.4

It may be seen from the results that the measured airspeeds vary quite considerably for different measurement locations. Also the distribution of airspeeds is substantially different for the two different fan designs. It should be noted that attempting to compare the performance of different fans by measuring the airspeed at one single location would be likely to produce misleading conclusions.

The highest airspeed measured at any location for each fan is almost identical:

- Two blade fan 19.0 m/s
- Four blade fan 19.1 m/s

However the four blade fan produces a wider jet, with the highest speeds occurring on a ring around the centre of the jet.

Averaging the measured speeds at 33 locations from 2.5m left to 2.5m right, I calculated the following average speeds:

- Two blade fan 9.6 m/s
- Four blade fan 12.0 m

From these results, I calculated that the four blade fan produced about 25% more airflow than the two blade at their respective standard operating speeds. Therefore the four blade fan is more effective for protecting crops against frost.

Yours sincerely

A handwritten signature in black ink, appearing to read 'Paul Carpenter', with a stylized flourish at the end.

Paul Carpenter
Research Leader, Aerodynamics