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Comparison of Technical Specifications and Performances of Wind Machines

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Abstract: Agricultural practices are always under natural disaster risks since farms are open areas to meteorological factors. These risks can be classified as snow, hurricane, flood, tornado and frost. Frost, one of the most important one of these risks, especially affects fruit gardens and has a 30% of total damage in vegetable production. Till now farmers have used to burn bales or plastic wheels to produce a heat cover in the gardens to protect trees. Today more technological method of frost protection which is wind machine is used to avoid frost. Wind machines are commonly used in Adana since fruit gardens are so susceptible due to wide open gardens and often frost occurrences in season changes. In this research 3 different make and model of frost protector wind machines' technical specifications and performances are determined. According to the results it was found that two different power groups of wind machines are commonly used. It was also determined that these machines have protection radius of between 100 to 136 meters and protection area between 3 to 6 hectares. According to the test results, the air flow has an effect between 2 to 5 meters from the ground. The sound pressure levels of these machines were over 85 dBA which is determined as the highest sound pressure exposure level by ILO (International Labor Organization).
Key words: Agricultural frost, frost protection, wind machine

INTRODUCTION

Agricultural frost is one of the most dangerous risks in agriculture which is caused by dropping of air temperature under 0 °C. There are different explanations of frost in literature but, frost can be generally defined as; "A "frost" is the occurrence of an air temperature of 0 °C or lower, measured at a height of between 1.25 and 2.0 m above soil level, inside an appropriate weather shelter" (Snyder, Melo-Abreu, 2005).

There are two types of agricultural frost which are advection and radiation. Advection frost occurs when cold air flows fast into an area filled with hotter air and takes place of it (Gulik, 1988). On the other side, radiation frost is the most difficult to be protected and it occurs at nights related to dry air and loss of mid or high speed of winds, presence of inversion and low humidity. Radiation frost occurs since cooler air causes more energy to be lost from earth's atmosphere and surface. Because of air does not loose it's heat as fast as earth's surface, hotter air will become in contact with the colder surface and cooler air come closer to the earth's surface and there will be a temperature inversion. Thus, frost occurs because of cooler and heavier air mass. The air which is up to 15 meters high from surface could be hotter than earth's surface having temperatures up to 6 to 8 °C.

Middle Anatolian area which has inland climate and Mediterranean region where greenhouses are very common are under the highest risk of agricultural frost. In 2010, for vegetable production agricultural frost had the highest insurance payment by TARSİM with 32.4 million TL which is 35% of 90.8 million TL (Kadıoğlu, 2012). In Turkey, agricultural frost occurs in 27th of September in Eastern and Middle Anatolian region and in shore sides it occurs till late of 26th of December. In Mediterranean region, agricultural frosts begin to occur late after 26th of November and finish in 16th of March. Citrus which is commonly produced in Mediterranean region is mostly in danger of agricultural frost which occurs in December. Each type of citrus has different sensitivity to agricultural frost. It was determined that satsuma mandarin has low, grapefruit and orange has middle and lemon has high sensitivity to agricultural frost (Greisel, 2003).

There are different methods to avoid frost. These methods can be divided into two which are active and passive methods. Suitable selection of production area, use of barriers, determination of the most suitable production period, selection of product and production method are the passive methods of protection against agricultural frost. Fencing, synthetic mist, burning of bales and use of wind machines are the active methods to avoid agricultural frost (Gulik, 1988). Today, use of wind machines is the most accepted method by farmers for agricultural frost protection.

Figure 1. General view of wind machine

The method that wind machines use is mixing cooler air closer to the earth's surface with hotter air in the higher air layer. Wind machine has a tower which is 10 to 15 meters high, a propeller with 2 to 4 blade which is placed on top of the tower with between 4 to 6 degrees to vertical plane and an internal combustion engine placed at the bottom of the tower (Fig. 1). When the inversion occurs, machine starts working so as to penetrate the hotter air which is placed over the production area to mix with the cooler air stays still in the lower layers of air.

In this research, three wind machines with different technical specifications which are sold in Turkey and their effective radius, fuel consumption, effect on temperature difference and sound levels were determined.

MATERIALS and METHODS

The machines used in this research were selected which are mostly sold models in Adana region and were set up in citrus gardens. Whole machines were built stationary in the garden and start to work automatically or manually according to the sensors and software. Some of the technical specifications according to these machines were given in Table 1. As given in Table 1, whole machines' tower height was the same, propeller diameters were 5820 mm for A and B and 6000 mm for C machine and number of blades were 2 for A and B and 3 for machine C. Engine power size of the machines B and C were 175 HP and B was 135 HP. Machine A was set up in a garden with 2.5 m tree gap, 2.7 m crown height and 2.6 m crown width, machine B was set up in a garden with 1 m tree gap, 2.5 m crown height and 1 m crown width and machine C was set up in a garden with 2 m tree gap, 2.5 m crown height and 2 m crown width. Trials were conducted in the morning between 06:00 to 08:00. For determination of the wind machines' coverage area, wind speed and temperature were measured at the distances of 5, 20, 50, 80 and 100 meters from the wind machine. Wind speed measurements were made at heights of 1, 2, 3, 4, and 5 meters from the ground, on the other hand temperature were measured at 1-meter height from the ground. In measurements of wind speed and temperature, 5 hand held anemometers were used (Figure 2a). Sound level of the wind machines were measured at ear level at each wind speed measurement point using Bruel&Kjaer 2250 sound pressure analyser with a Bruel&Kjaer 418 model microphone (Figure 2b)

Table 1. Technical specifications of wind machines

Machine Name	A	B	C
Tower Height	10400 mm	10400 mm	10400 mm
Propeller Diameter	5820 mm	5820 mm	6000 mm
Number of Blades	2	2	3
Propeller Slope Related to Vertical Line	4 degrees	5 degrees	6 degrees
Propeller Speed	580 min^{-1}	585 min^{-1}	430 min^{-1}
Test Area Size	3.7 hectares	11.3 hectares	10 hectares
	Engine Specifications		
Engine Power (HP)	135	175	175
Number of Cylinders	4	4	6
Fuel Tank Capacity (L)	500	500	500

Figure 2. Hand held digital anemometer for measuring wind speed and temperature and Bruel&Kjaer 2250 sound pressure meter

Fuel consumption of the test machines were calculated by measuring used fuel from the fuel tank.

RESULTS and DISCUSSION

Total turn around on propeller's axis time for each propeller head was found as 4 minutes 30 seconds. According to this result wind speed changes for each type of machine based on different measurement heights from ground was given in Figure 4. It was found out that the height wind speed was acquired in machine B. This machine was followed by machines A and C, respectively. Moreover, for each type of measurement points it was found out that effective distances for each machine was found between 20 to 80 meters.

Wind speed measurement graphics from different distances from the machines based on height from the ground were given in Figure 5. According to the results, it was determined that for each machine wind speeds at 5 and 20 meters were getting higher with the height from ground. After the distance of 50 meters from the machines, wind speeds were not depended on the heights from the ground level. It is thought that for each machine wind distribution was the same based on propeller angle.

For machine B, the distance of 80 meters from the machine wind speeds were higher between 1 to 3 meters from the ground, whereas wind speeds were getting higher with the height from the ground for machine A but getting lesser for machine C. Propeller angles were 5°, 4°, and 6° for machines B, A, and C, respectively. It was thought that the air flow changes for each machine was depended to propeller angle.

As a result, total coverage area for the machines were determined as 3, 5.8 and 6 hectares and coverage radiuses were 100, 136 and 136 meters for machines A, B and C, respectively.

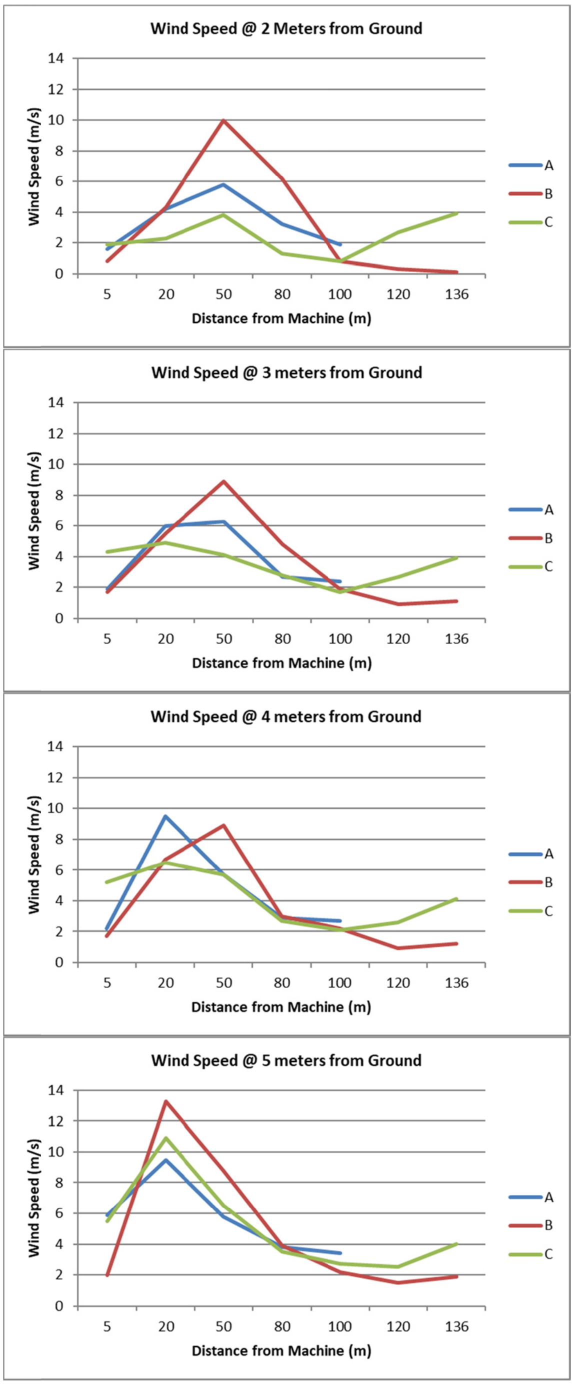

Figure 3. Measured wind speeds at different distances from machines based on height from the ground

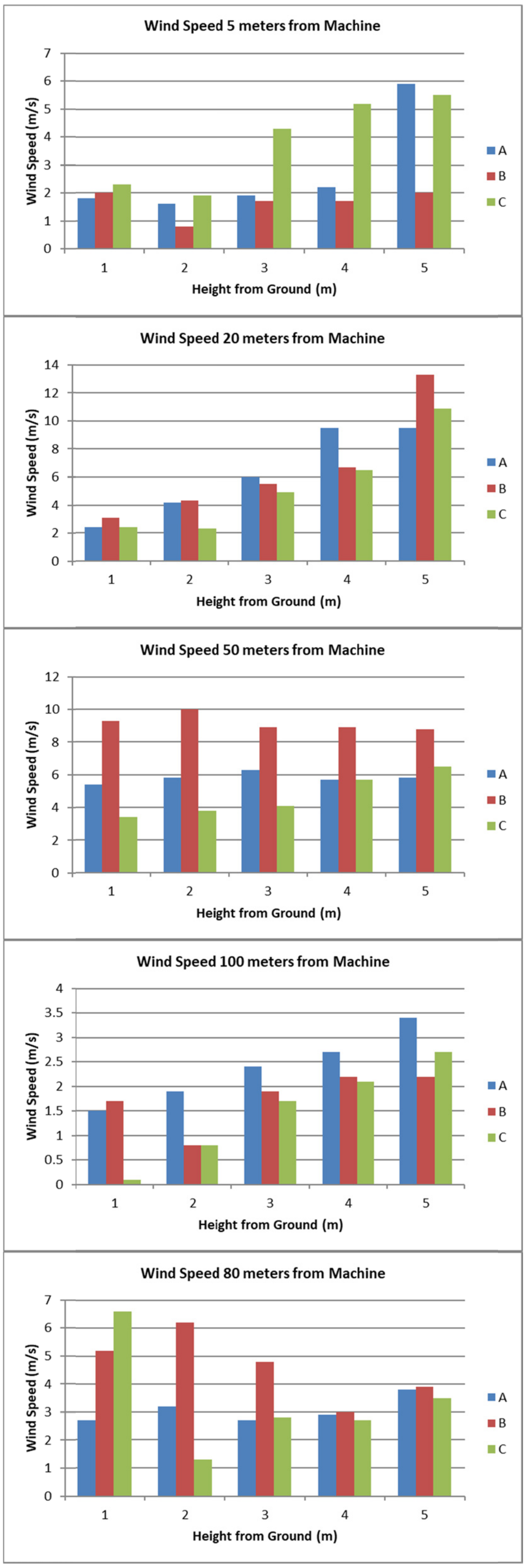

Figure 4. Wind speed at different heights from the ground based on distance from machines

If height from ground level dependency is ignored, machine B had the highest wind speed followed by machines C and A. For all machines, effective wind speed distance from machine was between 20 to 80 meters (Figure 6).

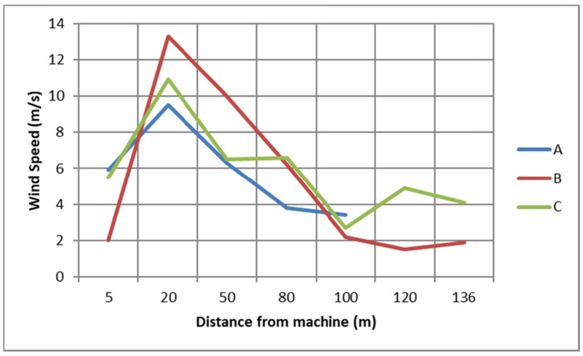

Figure 5. Wind speed changes based on distance from machines

When temperature changes were investigated at the height of 1 meter from the ground, it was determined that each machine had an effect to change air temperature (Figure 7). This change was little for A and C machines except machine B. Machine B had higher change of air temperatures between 50 to 80 meter distances. This result occurred due to trials were made at 0 °C air temperatures for machines A and C and 11.3 °C air temperatures for machine B.

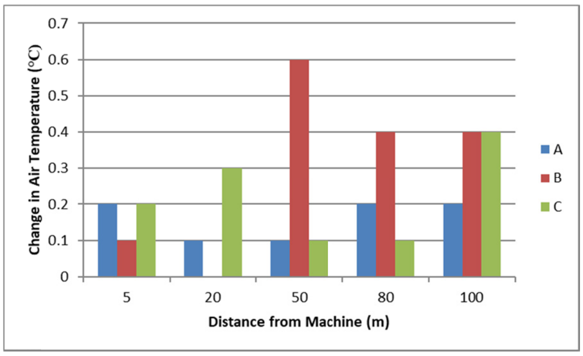

Figure 6. Air temperature change developed by the machines

According to the trials that were done in specific distances from machines it was found out that all machines sound pressure levels exceeded 85 dBA which is defined as the highest sound pressure exposure level by ILO (International Labour

Organisation). Up to 50 meters from the machines, especially B and C machines exceeded highest sound pressure levels. For machine A, it was determined that starting from 20 m sound pressure level dropped under maximum exposure level.

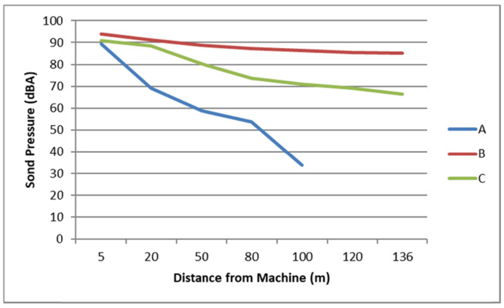

Figure 7. Measured sound pressure for tested wind machines

For each machines' fuel consumption was 18, 22 and 26 L/h for machines A, B and C, respectively.

CONCLUSION

In this research 3 different make and model wind machines which are commonly used in Adana region were tested for efficiency of lessen the effect of frost in citrus fruit gardens. According to the results; all wind machines have an influence on frost protection. The interviews that were made with the users were also proved the results of the measurements.

High air circulation effects were measured between 20 to 80 meters for all machines. The coverage areas were measured as 6 ha for machines B and C with 175 HP and 3 ha for machine A with 135 HP. It is thought that engine power and revolution per minute influences the coverage area size. It is also thought that, the material used in production of the propeller influences the developed wind speed and propellers should be tested in a wind tunnel to get the most of these machines.

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