Studies on Measures against Typhoon for Horticultural Facilities in the Southwest Islands

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Summary

The gardening facility is essential for the progress of agriculture in the southwest islands. It contributes greatly to the stable crop production not only for the typhoon protection but also for the pest management and the temperature management. In Okinawa prefecture, 42% of the gardening facilities are steel plastic houses as a countermeasure against potential typhoon damages. The steel plastic house requires a high cost and it seems difficult to set up the facilities without substitution. In this study, the gardening facility to resist wind with a low cost has been developed by the improved technology against typhoon in the southwest islands.

In Chapter 1, researches on the gardening facilities and windbreak facilities have been reviewed. Moreover, the status of using the gardening facilities in Okinawa Prefecture was described in detail.

In Chapter 2, the airflow characteristics of eleven anti-insect screens used in the southwest islands were evaluated by means of a wind tunnel. The thread diameter of anti-insect screens ranged from 0.17 to 0.29 mm, and the porosity ranged from 0.25 to 0.68. Wind tunnel experiments indicated that the pressure loss through the screens was a function of porosity. Specifically, the pressure loss increased when the porosity decreased, even if the pores were approximately the same size. For instance, the pressure loss increased to 1.6 times when the porosity decreased by 18%. It is recommended to examine the porosity, not the pore size, for the airflow characteristics of the anti-insect screens. The pressure loss through a screen was found to be a quadratic function of its porosity for a constant airflow velocity through the screen.

In Chapter 3, Typhoon 0314 attacked Miyako Island on September 10-11, 2003. The maximum instantaneous wind speed of 74.1 m/s was recorded and this is the seventh record in Japan. The damages of commercial greenhouses by the typhoon were investigated in sixteen locations. The damages were categorized into 1) cracked the concrete foundation, 2) breaking of end plate for the base of column, 3) breaking or looseness of the bolt which joint beam and doorjamb, and 4) broken weld zone. These damages caused by the strong winds have not been reported in the past in Okinawa. The collapse patterns of the greenhouses covered with only insect screens were similar to other greenhouses, the bases on the windward gable end of which were pulled out. The analysis showed that the base could be pulled out at a wind speed of 46.4 m/s or higher because of the weak resistance against the wind forces to be pulled upward. Moreover, the analysis showed that the weld zone of clamps of a square steel pipe plastic house was fractured by the side load caused by wind speed of 37.5 m/s or higher.

In Chapter 4, many greenhouses in Okinawa islands are frequently damaged by hitting of large-scale typhoons in these years. These damages caused by the strong wind loads have not been reported in the past in Okinawa. In order to improve the strength and reliability of greenhouses for Okinawa horticultural farmers, the new greenhouse that endure the load by the gusts of up to 50 m/s was developed based on the analysis of the damage. The greenhouse allows opening and closing of the vinyl sheet for temperature management of the inside of the greenhouse, and is designed to withstand typhoon gusts to the closing state of the vinyl sheet. To prevent deformation of greenhouse beams, the reinforcement method with wire rope was proposed.

In recent years, the intensity of typhoons has increased causing great damage to gardening facilities in not only Okinawa but also the mainland of Japan. Through the truss structure to large - scale green houses were tried to apply to wind - resistant houses, the introduction of such a structure involves very high costs. For implementation in agriculture, it is necessary to reduce the cost of introducing such a structure. In this study, a large size greenhouse with the truss structure at low cost using resin joints, which are light weight and inexpensive has been developed.

In Chapter 5, performance of the uneven dual-screen windbreak (UDSW) to protect agricultural products from the strong wind was tested when the typhoon 0310 attacked Okinawa. The test area surrounded by the UDSW was located on a plateau near a cliff. Wind speed was measured by ultrasonic anemometers at 6m high from the ground at the outside of the test area and 3m and 6m high at the inside. The relations between the distance from the cliff edge and the average wind speed were indicated a quadratic function of the distance in the range of 40m from the edge. These calculated data by a quadratic function were compared with the measured data. The wind speed at 28m leeward from the UDSW was reduced by 25% at a height of 6m, and that at 90m leeward was reduced by 17%. The wind speed ratio at a height of 3m to 6m was increased with distance from the UDSW about 0.83 to 0.92.

In this study, the multi-point observation system using wireless transmission was developed to observe the strong wind during the typhoon raid, and the feature of the sonic anemometer was examined from the comparison with the wind mill anemometer. It was shown that sonic anemometer is able to measure the strong wind during the storm. This system can be used enough range more than 300m. Moreover, this system can synchronize the data from 11 sonic anemometers by up to 50Hz sampling rate. This system can be available even in the field where the electric power cannot be supplied. Two solar cells and two deep cycle batteries were used for the power supply on the client side. As a result, the system can be operated continuously about 3 days.

Subject for a further study is a quantitative research to evaluate a wind resistance of the facilities covered by net. Moreover, it is necessary to research economic efficiency such as initial construction and maintenance costs. The research about maintenance technique for long-term used of the gardening facilities are also important. These studies contribute greatly to the development of agricultural industry in the southwest islands.