

Development of a wind protection device for crops on plateaus near cliffs

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Abstract

The purpose of this study is to examine the performance of a wind protection method for crops against strong gale especially on cliffy islands like Japan attacked by typhoons, to suggest the best placement of a wind protection device. The detailed characteristics of the wind by typhoons on a plateau near a cliff edge were observed by using ultra-sonic anemometers as primary data for this study. Then, the wind protection performance of the Uneven Dual-Screen Windbreak (UDSW) that was originally designed by the authors was estimated on the basis of the previous data.

This observation was carried out Okinawa prefecture in Japan. Okinawa consists of small islands, which is located southernmost of Japan and frequently attacked by typhoons. Typhoons bring very strong wind and very high concentrated precipitation to a limited area. For example, the observatory of Miyako Island recorded 74.1m/s as maximum instantaneous wind speed of the Typhoon 0314 (Maemy), and it is not rare case that the wind speed of over 60m/s was observed at anywhere in Okinawa. These typhoon attacks make it difficult to maintain stable management of cultivation and agricultural products. The primary data of the strong gale by typhoons were observed at Miyagi Island, a small island connected by bridges with the main island of Okinawa. The terrain of Miyagi Island is a plateau like a small table mountain of which the top is an almost flat agricultural field of 1.13square km at a height of 90m from the sea level. The flat top is surrounded with cliffs covered by woods of about 6m high. The characteristics of UDSW are its shape and material. It consists of two rows of screens that made from nets with a 1mm mesh. These two rows are arranged upper and lower level with a horizontal distance of 80cm. The top and the bottom of the upper row are 4m and 2m from the ground level, while the lower row consists of the same size screens placed on the ground. The UDSW was set in a rectangular shape whose sides are 120m and 100m for the observation. Wind speed distributions in observation area were measured during the typhoons of 0310(Etau), 0315(Choi-wan), 0418(Songda) and 0421(Meari). The maximum instantaneous wind speeds measured at Miyagi Island were

54.4m/s, 30.1m/s, 18.4m/s and 36.4m/s, respectively. The main wind directions used in analyses were not same respectively. In addition, the data of typhoon 0310 was used to examine the performance of the UDSW.

The result shows that the mean wind speed increases with distance from the cliff edges in all the wind directions, while the turbulence intensity tended to decrease. Especially, within the range of about 300m from the cliff edges, the wind increased rapidly, then after that the increase of the speed slowed down. The relation between the distance from the cliff edge and the mean wind speed is almost fitted to a quadratic function. On the other hands, 6m high wind speed was nearly constant after 500m from the cliff edge. And we confirmed disappearance of distance dependency after 700m. However, the mean wind speed of 3m high increased with distance from cliff edge, while turbulence intensity decreased. It is considered that the mean wind speed effected by wind protection of about height 6m of windbreak forest on cliff edge.

The effect of wind protection of UDSW was as follows. The windbreak screens are effective to decrease the wind speed. However, occasionally the screens shade the crops and the weakened wind brings increase of diseases and pests in agriculture. From these points of view, the amount of windbreak screens should be equipped as small as possible. The previous observation data indicated that the UDSW weakens the wind speed by 25% at a height of 6m and by 17% at 90m leeward from the screen, and the ratio of the wind speed at a height of 3m to that of 6m was 0.9 or less.

From these results, the following method for windbreak is recommended: First, What is important in protecting the crops is to set windbreak forest and facilities on edge of cliff. in the next place, Windbreak facilities like the UDSW should be set every 100m in the areas over 400m from the cliff edge. Further analyses on the effects of topography and/or artificial objects on the wind speed distribution will suggest the optimum arrangement for the UDSW.