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Prediction of Effects of Global Warming on Apple Production Regions in Japan

By

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Key words : Climate change, mesh climate data, producing district, suitable regions.

Summary

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Most of apple trees have been cultivated in the northern part of temperate zone in Japan, since they are suitable for planting in cold climates. The crops produced in a cold area may be greatly influenced by warming. This study is undertaken to assess the impact of global warming on the production of apple (*Malus domestica* Borkh.) in Japan. The temperature ranges assumed to be appropriate for the cultivation of apple are 6-14°C on annual mean temperature and 13-21°C on mean temperature from April to October, respectively. The database of "Climate Change Mesh Data (Japan)" was used to simulate possible changes in favorable regions for the cultivation of apple with approximately 10 by 10 km resolution. The mesh data derived from IPCC IS92a-type emission scenario and four Atmosphere-Ocean General Circulation Models (A-O GCMs). It was predicted that the favorable regions to cultivate apples will gradually move northward. All the plains of southern Tohoku in 2040's and central Tohoku in 2060's will be unfavorable for apple cultivation, while most of regions in Hokkaido will be suitable by 2060's. Many parts of the current apple producing districts in Japan will be possibly unfavorable by 2060's. Therefore, global warming will greatly affect the cultivation environment of apples in Japan by the middle of the 21st century.

Introduction

The fruit trees are heavily dependent on the climate. Most of apple trees have been cultivated in the northern part of temperate zone in Japan such as the south end of Hokkaido, Tohoku and inland areas of central Japan, since they are suitable for planting in cold climates. Early planting are possible adaptation strate-

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gies of the management systems to climate change on cereal crop (SEINO 1995). But fruit trees productions are vulnerable to rise in air temperature since it is difficult to change cropping season of perennial crop such as fruit trees. Furthermore, the fruit trees can not be easily replanted which need several years until growing up to the productive age. Therefore, global warming will resite suitable areas for apple production.

Trees often suffer cold injury under cold environment. Inhibiting endodormancy completion, reducing flowering bud and succulent growth of shoots (MIZUTANI & al. 1984) would be caused when apple trees are cultivated under high temperatures. Changes of suitable areas for apple production in Japan were estimated from only changes of annual mean temperature which was used as simple index to estimate trees growth affected from chilling requirement and cold resistance (SUGIURA & YOKOZAWA 2004).

A certain amount of accumulative temperature during fruits growing period is needed for fruit development, while coloring the pericarp of apple is inhibited by high temperatures (ALBRIGO & CHILDERS 1970, CREASY 1968, YAMADA & al. 1988). TOMANA & YAMADA 1988 indicate that fruit qualities of apple are affected by mean temperature in fruit growing season.

The suitable areas for apple production were decided from annual mean temperature and mean temperature in fruit growing season in "Basic policy for fruit-growing industry promotion" provided by the Ministry of Agriculture, Forestry and Fisheries in 2000. The objective of this study is the simulation of change on the favorable regions to cultivate apples in Japan from the two conditions to predict age and area in which influences of Global warming appear.

Material and Methods

In "Basic policy for fruit-growing industry promotion", the temperature ranges assumed to be appropriate for the cultivation of apple (*Malus domestica* Borkh.) are 6-14°C on annual mean temperature and 13-21°C on mean temperature from April to October, respectively. The two conditions were used to simulate possible changes in favorable regions for apple production.

The database of "Climate Change Mesh Data (Japan)" (YOKOZAWA & al. 2003) was used to simulate them with approximately 10 by 10 km resolution. The mesh data derived from IPCC IS92a-type emission scenario and four Atmosphere-Ocean General Circulation Models (A-O GCMs), which A-O GCMs were ECHAM4/OPYC3 (Germany), CGCM1 (Canada), CSIRO-Mk2 (Australia), and CCSR/NIES (Japan). The monthly mean air temperatures of the database on each A-O GCM were averaged to calculate annual mean temperatures and mean temperature from April to October at each mesh. Mean rising rate of the estimated temperature among the four A-O GCMs from 2000's to 2060's was 0.37°C/10 year. For the current annual mean air temperatures, the value in the database of "Mesh Climatic Data of Japan" (JAPAN METEOROLOGICAL AGENCY 2002) were used, which had estimated from statistics at meteorological observing station from 1971 to 2000.

Results and Discussion

The favorable regions for apple production under current climate distributed to southern Hokkaido, most of Tohoku area and inland areas of central and western Japan (Fig. 1 A). The regions covered the current main apple producing districts.

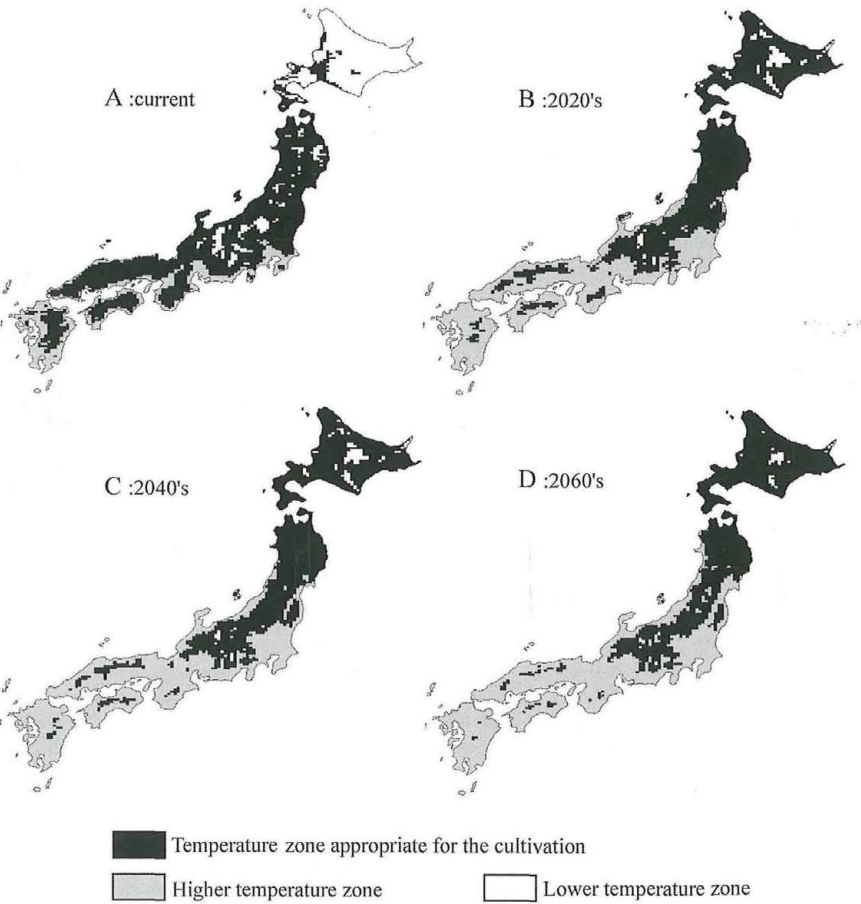


Fig. 1. Spatial distribution of favorable regions for apple production, assuming that the annual mean temperature and mean temperature from April to October appropriate for apples range 6-14°C and 13-21°C, respectively, under (A) current climate (1971-2000), (B) climate in 2020's, (C) climate in 2040's, (D) climate in 2060's.

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The changes of the favorable regions to cultivate apples estimated by using the database of "Climate Change Mesh Data (Japan)" were shown (Fig. 1B, C, D). These figures indicated that the favorable regions would gradually move northward. Most of the plains of Hokkaido will be suitable for apple production in 2020's. In 2040's the plains of southern Tohoku will be predicted to attain the temperatures zone higher than the current main producing districts. The plains of central Tohoku will be possibly unfavorable regions to cultivate apples by 2060's, while all regions in Hokkaido will be suitable excluding cold upland by 2060's.

Many parts of the current apple producing districts in Japan will be possibly unfavourable by 2060's. Therefore, global warming will greatly affect the cultivation environment of apples in Japan by the middle of the 21st century. To decide southern and northern limits for detailed prediction in future studies, it is necessary to consider the temperature during fruit coloring period, chilling unit accumulation during endodormancy period and changes of resistance of buds and twigs to low temperature.

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