

Changes in locations suitable for satsuma mandarin and tankan cultivation due to global warming in Japan

Journal or Publication Title :

Acta horticultrae

Number :

1130

Page Range :

91 – 94

Year :

2016.12

Item Type :

学術雑誌論文 / Journal Article

Note:

注記

この論文は出版社版ではありません。引用の際には出版社版をご利用ください。

This is not the published version. Please cite only the published version.

© International Society for Horticultural Science

The original publication is available at <https://doi.org/10.17660/ActaHortic.2016.1130.13>.

Changes in Locations Suitable for Satsuma Mandarin and Tankan Cultivation due to Global Warming in Japan

T. Sugiura, D. Sakamoto, Y. Koshita, H. Sugiura and T. Asakura
NARO Institute of Fruit Tree Science, National Agriculture and Food Research
Organization
Tsukuba
Japan

Keywords: annual mean temperature, climate change, GCM, mesh data, subtropical citrus

Abstract

Satsuma mandarin, a temperate citrus species, is the leading fruit tree species in Japan, and the changes in the suitable locations due to future global warming have been already predicted. To offer satsuma mandarin producers information for making a decision of replanting, we simulated future locations suitable for the cultivation of satsuma mandarin and tankan, a subtropical citrus species, considering the uncertainty created by variation in climatic predictions. Simulations were done on the basis of future annual mean and minimum temperatures evaluated by 6 general circulation models under the SRES-A1B GHG emission scenario. The results indicated that the locations suitable for satsuma mandarin would gradually expand northward and inland. However, the judgment of locations suitable or unsuitable depended on the GCMs in many regions during 2041–2060 and few regions were classified by all GCMs as suitable during 2061–2080. The locations suitable for tankan will expand northward, however, a few suitable locations will be the inland of Japan during 2021–2040. Therefore, if increased global warming causes declines in satsuma mandarin production, then tankan could be produced as a substitute in the coastal areas of current satsuma mandarin-producing regions. However, it will be difficult to produce tankan in the inland areas of these regions due to cold injury in fruits for the next few decades.

INTRODUCTION

Our previous studies on the impacts of climate change on fruit production in Japan have demonstrated changes in meteorological disasters (Sugiura et al., 2012), fruit quality (Sugiura et al., 2013) and the particular locations suitable for fruit production (Sugiura and Yokozawa, 2004; Sugiura et al., 2014). Compared to most crops, tree crops will require earlier action by farmers because such crops cannot be replanted easily and require several years to grow from nursery stock to the fruit-bearing stage.

Satsuma mandarin (*Citrus unshiu* Marcow), a temperate citrus species, is the leading fruit tree species in Japan. Although it is one of the most cold-tolerant of the commercial citrus species grown in the world (Lindsey, 2008), high-temperature damage often occurs in warm years (Sugiura et al., 2007).

When cultivation of satsuma mandarin becomes difficult, converting to the cultivation of citrus species with high-temperature tolerance such as tankan (*Citrus tankan* Hayata), the leading subtropical citrus consumed fresh in Japan, would be an effective adaptation strategy owing to the relatively narrow technical gap between these two crops.

Researchers have predicted that locations suitable for satsuma mandarin (Sugiura and Yokozawa, 2004) and tankan (Sugiura et al., 2014) cultivation will move due to global

warming in the future. However, the results of the two studies could not be compared on account of difference in methods and uncertainty of prediction was not assessed. In this study, we simulated future changes in locations suitable for the cultivation of satsuma mandarin and tankan and the uncertainty created by variation in climatic prediction. Our findings will provide satsuma mandarin producers better information for making replanting decisions.

MATERIALS AND METHODS

For the current air temperatures, we used values of daily mean and minimum air temperatures during 1981–2000 in the AMeDAS mesh data (Seino, 1993), a mesh climate dataset (each grid cell measures 45" in longitude × 30" in latitude, i.e. about 1 km square) estimated using statistics at meteorological observation stations across Japan

Projected air temperatures of each grid cell during 2021–2040, 2041–2060, and 2061–2080 were calculated from Mesh Climate Change Data of Japan v. 2 (Okada et al., 2009), which is a mesh climate dataset (45" × 30") covering 1900–2100 estimated from climate evaluated by some atmosphere–ocean coupled general circulation models (GCMs). In this study, we used the projection calculated by the 6 GCMs (BCCR, CSIRO-30, GISS-AOM, INMCM3, MIROC-H, MIROC-M) under the SRES-A1B GHG emission scenario in the dataset.

Monthly mean and minimum air temperatures were defined as the average of the daily mean and minimum air temperatures in each month. Monthly increases in temperatures for the period 2021–2040 relative to 1981–2000 were calculated as the difference between the 20-year average of monthly mean and minimum air temperatures in 2021–2040 and those in 1981–2000. Daily mean and minimum air temperatures of each grid cell during 2021–2040 were calculated as the sum of current daily mean and minimum air temperatures (i.e., 1981–2000 in AMeDAS mesh data) and each monthly increase in mean and minimum temperatures during 2021–2040. Daily mean and minimum air temperatures during 2041–2060 and 2061–2080 were determined similarly.

Suitable locations for satsuma mandarin cultivation were assumed to be areas where the average annual mean temperature for 20 years was from 15 to 18°C, and in less than 5 of every 20 years the annual minimum temperature was less than -5°C (MAFF, 2010). Suitable locations for tankan cultivation were assumed to be areas where the average annual mean temperature was at least 17.5°C, and in less than 5 of every 20 years the annual minimum temperature was less than -2°C (Sugiura et al., 2014).

RESULTS AND DISCUSSION

Under the current climate regime, locations judged as suitable for satsuma mandarin cultivation were distributed across most of the Pacific coastal area in central and western Japan (Fig. 1). Most of the estimated suitable locations covered the current main mandarin-producing regions. The simulation indicated that the suitable locations will gradually expand northward and inland. However, the judgment of suitable or unsuitable for satsuma mandarin producing depended on the GCMs in many regions during 2041–2060. Few regions were classified by all GCMs as suitable during 2061–2080.

Under the current climate regime, locations judged as suitable for tankan cultivation were distributed across all of the remote islands located southeast of the main islands of Japan (the Nansei Islands, Fig. 2). Most of the estimated suitable locations covered the current main mandarin-producing regions. The simulation indicated that the suitable

locations will gradually expand northward, however, a few suitable locations would be in the inland areas of Japan during 2021-2040.

These results show that if increased global warming causes declines in satsuma mandarin production, then subtropical citrus such as tankan could be produced as a substitute in the coastal areas of current satsuma mandarin-producing regions. However, we predict that it will be difficult to produce tankan in the inland areas of these regions for the next few decades.

The lower limit of suitable annual minimum temperature for cultivation means the threshold temperature for cold tolerance. The threshold temperature for cold tolerance of tankan is higher than satsuma mandarin. Satsuma mandarin has one of the earliest ripening periods among the world's commercial citrus crops, with a harvest time from September to December in Japan. Tankan ripens in February. Granulation, a type of cold injury characterized by dry and bitter flesh tissues, often occurs when fruits are exposed to severe cold during January and February, which are the coldest months of the year in Japan (Takebayashi et al., 1993). Therefore, it may be difficult to produce tankan in the inland areas where the minimum air temperatures is lower than in the coastal areas.

ACKNOWLEDGEMENTS

This research was funded by the Environment Research and Technology Development Fund (S-8) of the Ministry of the Environment, Japan.

Literature Cited

- Lindsey, J. K. 2008. Economic evaluation of protection against freezes in satsuma mandarin production. Proquest, Umi Dissertation Publishing, Ann Arbor.
- Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF). 2010. Kajunogyo-shinko-kihinhoshin (In Japanese). MAFF, Tokyo.
- Okada, M., Iizumi, T., Nishimori, M. and Yokozawa, M. 2009. Mesh climate change data of Japan ver. 2 for climate change impact assessments under IPCC SRES A1B and A2. *J. Agri. Meteorol.* 65:97-109.
- Seino, H. 1993. An estimation of distribution of meteorological elements using GIS and AMeDAS data. *J. Agri. Meteorol.* 48:379-383 (In Japanese).
- Sugiura, T. and Yokozawa, M. 2004. Impact of global warming on environments for apple and satsuma mandarin production estimated from changes on the annual mean temperature. *J. Japan. Soc. Hort. Sci.* 73:72-78 (In Japanese with English summary).
- Sugiura, T., Kuroda, H. and Sugiura, H. 2007. Influence of the current state of global warming on fruit tree growth in Japan. *Hort. Res. (Japan)* 6:257-263 (In Japanese with English abstract).
- Sugiura, T., Sumida, H., Yokoyama, S. and Ono, H. 2012. Overview of recent effects of global warming on agricultural production in Japan. *JARQ* 46:7-13.
- Sugiura, T., Ogawa, H., Fukuda, N. and Moriguchi, T. 2013. Changes in the taste and textural attributes of apples in response to climate change. *Scientific Reports* 3: 2418.
- Sugiura, T., Sakamoto, D., Koshita, Y., Sugiura, H. and Asakura, T. 2014. Predicted changes in locations suitable for tankan cultivation due to global warming in Japan. *J. Japan. Soc. Hort. Sci.* 83:117-121.
- Takebayashi, T., Kataoka, T. and Yukinaga, H. 1993. Classification of 98 different citrus species and cultivars by fruit quality and their disorders as related to delayed harvest. *J. Japan. Soc. Hort. Sci.* 62:305-316 (In Japanese with English summary).

Figures

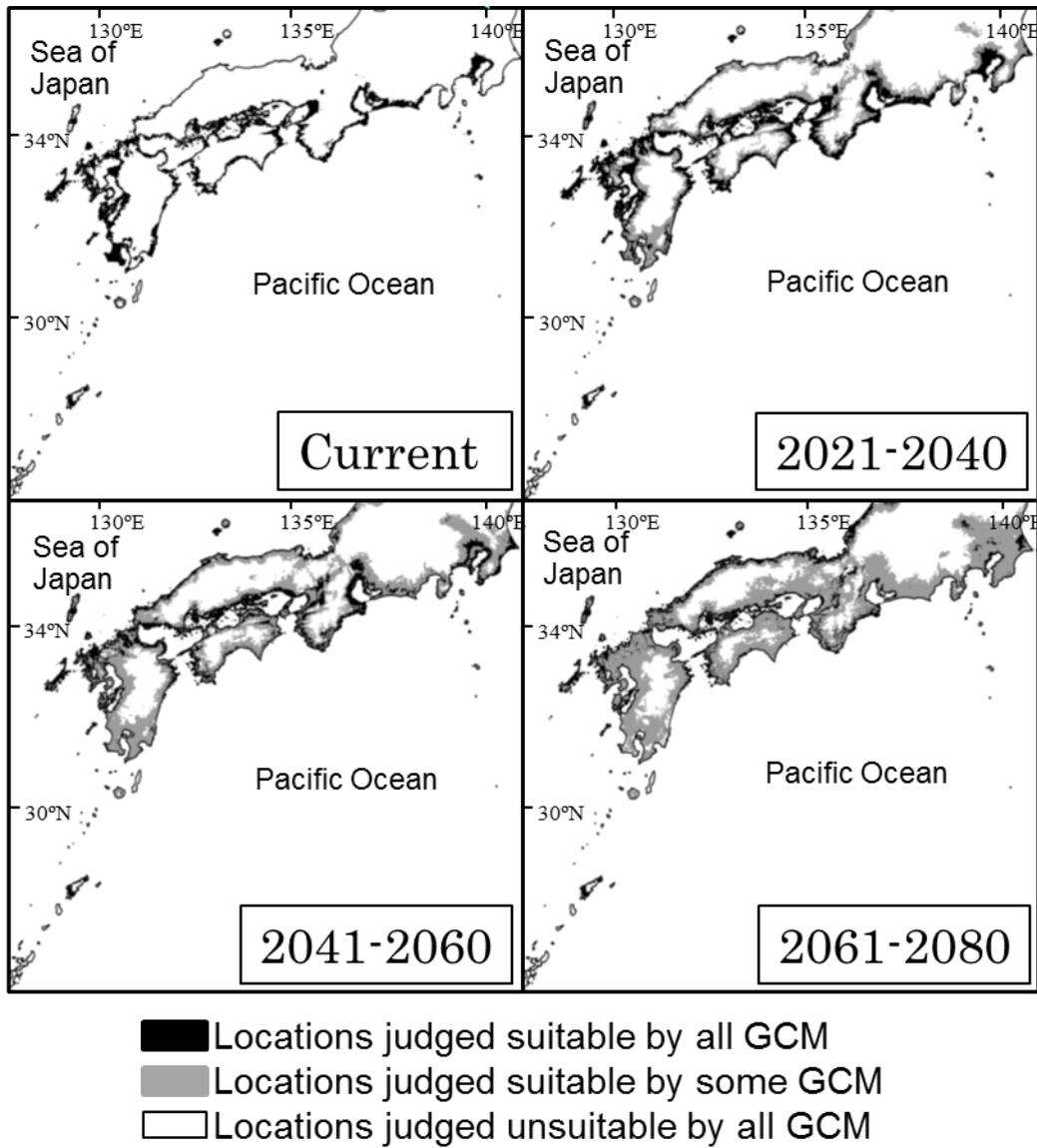


Fig. 1. Locations judged as suitable for satsuma mandarin cultivation in central and western Japan.

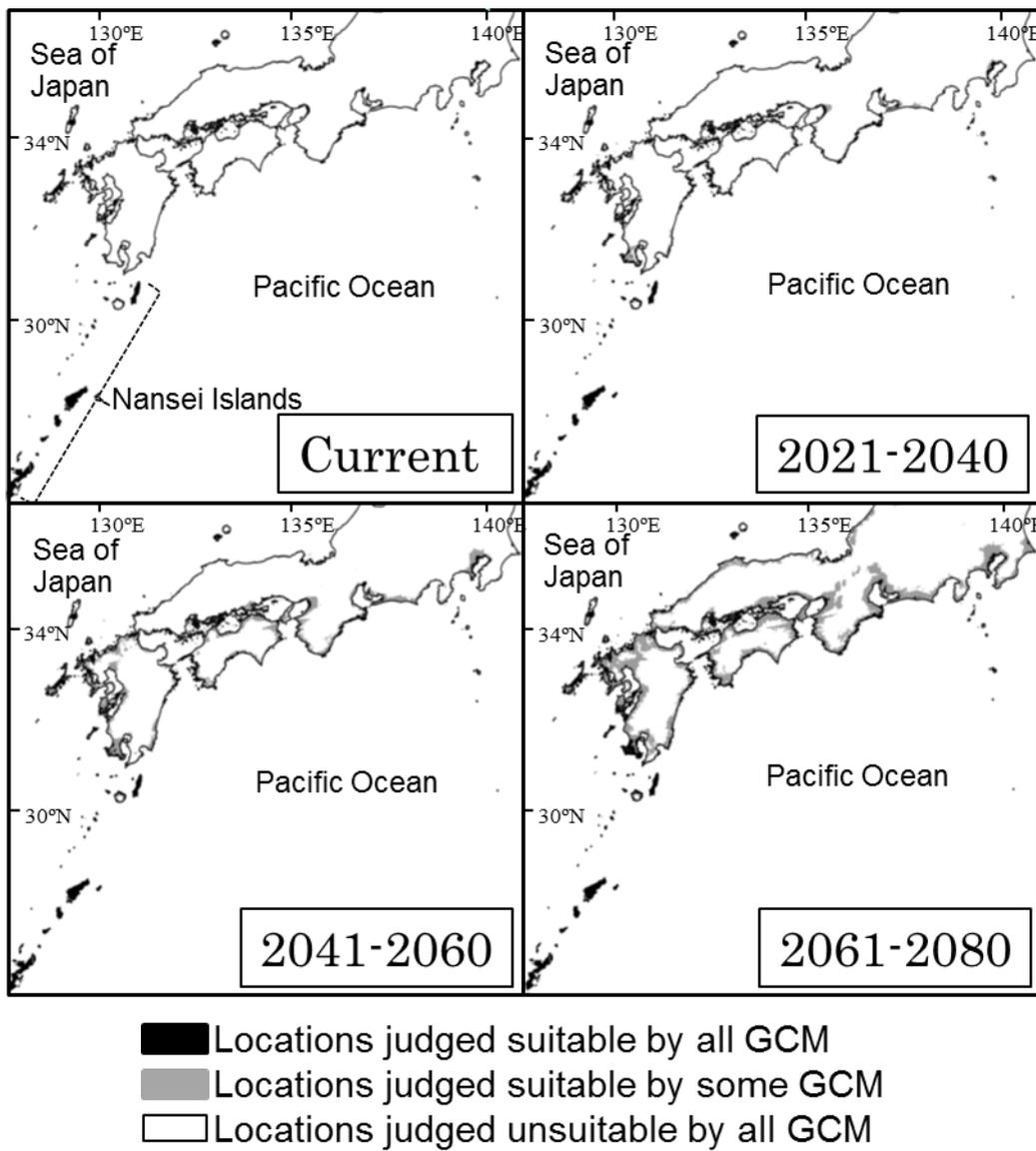


Fig. 2. Locations judged as suitable for tankan cultivation in central and western Japan.