The Impact of Global Warming on Agricultural Productivity in Hokkaido with Adaptation Strategies: Projections for the 2030s

Summary

Hokkaido, which produces twice the food it consumes, plays an important role as a domestic food supplier in Japan. Hokkaido’s agricultural community will need to estimate the effects of global warming on changes in agricultural productivity and to take appropriate actions in response to those changes to maintain this position during a time of rising unease about the future of the world's food supply. The goal of this study is to predict the potential impact of climate change and global warming on growth, yields and qualities of paddy rice, upland and forage crops in Hokkaido for the decade of the 2030s, and then to suggest some strategies for adapting to those changes.

Climatic conditions for the 2030s

Yokozawa *et al.* (2003) constructed "mesh climate change data of Japan" for the 2030s, which was used in this study. This dataset provides climatic data around Japan using the predictions of four different atmosphere-ocean general circulation models meshed together based on the IPCC IS92a-type emission scenario (IPCC, 1996) with a resolution of 7.5' in longitude and 5' in latitude or a resolution of about 10 × 10 km. This study primarily used the dataset estimated by the CCSR/NIES model developed in Japan. Based on this data, monthly mean temperatures in Hokkaido for the 2030s will increase by 1.3–2.9°C, or 2.0°C on average, when compared with present climatic normals as reported by the Japan Meteorological Agency and defined by data obtained from 1971–2000. The mean temperature from May to September, the main growing season in Hokkaido, will rise by 1.8°C, but annual mean global radiation will be reduced by 15% when compared with the present. The amount of annual precipitation in 2030s will increase by 20%, showing a large peak in precipitation during June and July.

For Hokkaido as a whole, the predicted productivity of paddy rice, upland and forage crops for the decade of the 2030s is summarized below and is compared with the present day situation, based on these predicted climatic conditions.

Paddy rice

The period of the appropriate heading stage for achieving both good yield and desirable food quality rice will be extended considerably, and then the risk of the occurrence of cool-summer damage caused by delayed growth will decrease. However, the risk of floral impotency may remain in the 2030s, because the critical growing period for spikelet sterility caused by low temperatures will still exist and will only be moved to an earlier date. Potential yield based on the changed weather conditions during the ripening period will be almost same

as the present or will increase slightly. The food quality of rice will be expected to improve because of lower amylose content and slightly lower protein content in grain resulting from a rise in the mean temperature during the ripening period.

Winter wheat

Both the raising (immediately after wintering) and maturing stage of winter wheat will be moved backward because of the early end of the snow cover period and a rise in the mean temperature after wintering. The number of days for ripening will be almost the same as the present. The crop model predicts an 8–18% decrease in potential yield because of a decrease in global radiation after May. The effect of stress caused by insufficient water on yield will decline but the risk of the occurrence of lodging and pre-harvest sprouting will be serious because of an increase in the amount of precipitation from the flowering to maturing stage. The sowing date will be delayed by 6–10 days.

Sugar beets

Sugar beet yield, measured by the weight of roots, will be expected to increase from 56 t/ha at present to 62 t/ha in the 2030s but sugar content of the roots will decrease from 17% at present to 16% in the 2030s because of a rise in temperature during the growing season, if the number of days of growth remains the same as at present. Disease injury which occurs easily at higher temperatures will appear earlier and will cause more serious damage to growth.

Potatoes

Potential potato yield predicted by the crop model will decrease by about 15% from the present, not because of an increase in temperature but mainly caused by a decrease in global radiation. An extended growing season, with an advanced planting date, will not compensate for this decrease in yield. Harvest time for late maturing varieties will moved backward from the end to the middle of September.

Soybeans

Both flowering and maturing stages in soybeans will move backward by 6–9 calendar days if the sowing date remains unchanged. The current climate zone map for introducing appropriate soybean varieties in Hokkaido is divided into 6 zones. It should be modified, because the zone classification will shift by 1 to 3 ranks toward the warmer class. Yield of the early maturing variety "Yukihomare" will increase in the area where the present mean temperature from June to August is below 18°C. But in the area where the present mean temperature during the same period exceeds 18°C, medium maturing varieties like "Toyomusume" whose yield improves under warmer temperatures should be introduced to offset the decrease in "Yukihomare" yield.

Adzuki beans

The flowering and maturing stage of adzuki beans will be moved backward by 7–10 calendar days, and the growing region for adzuki beans is expected to extend into cold areas like the eastern part of Hokkaido, where dairy farming now dominates. Yield will increase in relatively cool regions such as Tokachi and Ohotsuku, and decrease in warmer regions such as Kamikawa and Sorachi. Consequently, total adzuki beans production in Hokkaido will increase by 12% if the future cultivated area remains the same as at present. However, the size of beans will be smaller because of a rise in temperature during the period of maturation.

Grass

The first grass growing period will not change very much although the heading stage of the grass will be moved backward by 13 days. Annual yield will be reduced by 10–20% because of a decrease in global radiation despite a rise in temperature.

Forage corn

The total amount of forage corn production in Hokkaido will increase by 10–14% if the cultivated area remains the same. Forage corn will not only be affected by the rising temperatures but also by the effect of the change to later maturing varieties depending on how many degrees the temperature rises.

Adaptation strategies towards the 2030s

It is essential to promote the breeding of varieties of paddy rice, upland and forage crops which are both disease resistant and tolerant to various climatic conditions expected to occur frequently with the higher temperatures and wetter summer conditions forecasted the near future. For now, improvement of cool-weather tolerance, especially for paddy rice and winter wheat, is still necessary. As the climate changes some cultivation techniques for paddy rice, upland and forage crops should be modified, while changes will soon be needed in the choices of varieties for the region, sowing and planting dates, harvest time and fertilizer application methods. Effective countermeasures to offset the changes in occurrence of disease injuries, insect pests and to crop damage caused by excessive water in upland fields should be also developed.