PRODUCTIVITY OF ORCHARDGRASS IN JAPAN ESTIMATED BY THE NEURAL NETWORK METHOD AND THE EFFECT OF AN INCREASE IN CO_2 AND A RISE IN TEMPERATURE

H. Sasaki, T. Suyama and M. Fukuyama

National Grassland Research Institute, Senbonmatsu 768, Nishinasuno, Nasu, Tochigi, Japan

ABSTRACT

The purpose of this study is to estimate changes in the productivity of orchardgrass (*Dactylis glomerata* L.) resulting from an anticipated increase in CO_2 and a rise in temperature. Productivity of orchardgrass is primarily determined by mean temperature and solar radiation. Accordingly, a growth model was established on this basis by using the neural network method. Maps of areas where productivity is depressed in the summertime were drawn based on calculations applying anticipated climatic changes to this model. The direct influence of the increase in CO_2 density was also considered in making these maps. As a result, it was concluded that, in the future, the area adversely affected by summer heat will increase, while the area capable of sustaining high productivity will be reduced.

KEYWORDS

Climatic productivity, neural network, temperature rise, CO_2 increase, orchardgrass

INTRODUCTION

In recent years, scientists have been predicting that the greenhouse effect will dramatically change global weather patterns in the next century, that is, air temperature will rise in the coming years. It is therefore essential that those involved in grassland stockbreeding assess the effect of this rise in temperature and take all necessary measures to avoid any adverse impact that this change may have.

Orchardgrass is one of the main species of grass grown in Japan. Its growth is mainly limited by the very hot summers typical of this country. That heat adversely affects the growth of this grass is evidenced by the lower productivity in the southwestern part of the country, which is usually much hotter. It is anticipated that the rise of temperature will further stifle productivity.

The greenhouse effect, however, will not be entirely negative since the characteristic increase in CO_2, which increases grass productivity, will have a generally positive impact on the growth of orchardgrass. As a result, this study evaluated both the increase in CO_2 and the rise in temperature simultaneously.

METHODS

Three species of temperate grass, orchardgrass, tall fescue (*Festuca arundinacea* Schreb.), and perennial ryegrass (*Lolium perenne* L.), were cultivated for three years, during which time monthly productivity was recorded. A neural network, which takes into account 165 bits of productivity data, was constructed using temperature and solar radiation data. The input layer consisted of five cells, that is, the three species of grass mentioned above, the mean temperature, and the amount of solar radiation in each growth period. The middle layer consisted of three cells, while the output layer consisted of one cell, that is, dry matter production in each growth period. In this way, a growth model based on climatic factors could be constructed.

Data obtained from potted orchardgrass in the room where climatic conditions were artificially controlled was used to evaluate the effect of CO_2 on growth. This test was conducted at CO_2 densities of 350 ppm and 700 ppm, and monthly productivity was estimated by the ratios of six data. These ratios(>1) consisted of the production value at 700 ppm compared to the value at 350 ppm.

Moreover, zoning on the summer depression area were drawn by applying GISS (NASA Goddard Institute for Space Studies) scenario to this model. This data indicated that the temperature increase was lowest in climatic scenarios. The effect of the CO_2 ratio was factored into this calculation. And we regarded the area where dry matter production in August (the hottest month in Japan) was calculated to be under 3.5 g/m^2/day as a summer depression area.

RESULTS AND DISCUSSION

The data of growth model by using neural network had a high correlation with actual data (r = 0.89**). And this model explained well the features of temperate grass in Japan. That is, the higher the solar radiation, the higher the productivity. And productivity is highest at about 18 C, however, it becomes depressed with the rise of the temperature. This model also explained well the features which depend on species. That is, tall fescue is superior to the others as to the tolerance under the condition of the higher temperature, and perennial ryegrass grows better than the others under the lower temperature.

On the other hand the increase in CO_2 density affects productivity to the direction, where the more the temperature goes up, the more the ratio mentioned above is promoted . This relation was expressed by following equation, provided that the range of the temperature is more than 15 C.

$$\text{ratio} = 0.097 + 0.068 * (\text{temperature}) \quad (r = 0.95^{**}) \quad (\text{temperature} > 15\ \text{C})$$

Annual mean temperature in Japan increases about 4 C in GISS scenario as a whole. In applying the growth model to the place where our institute is located, summer depression becomes worse and orchardgrass can not survive in the next century. This result is shown in fig. 1, where pattern in the present is painted and in the future is striped.

As the next process, we carried out this calculation with all mesh data over Japan: we applied these climatic mesh data of current and of GISS scenario to the growth model. Then maps of areas where productivity is depressed in summertime in the present and in the future were drawn. The summer depression area was assumed to enlarge with the climatic changes as is shown in fig. 2.

As the area should also be examined, where tropical grass such as bahia grass (*Paspalum notatum* Flugge.) is to be cultivated, we are now investigating to estimate the productivity of this species.

REFERENCES

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Figure 1
Monthly productivity in the present (painted) and in the future (striped) in the middle of Japan.

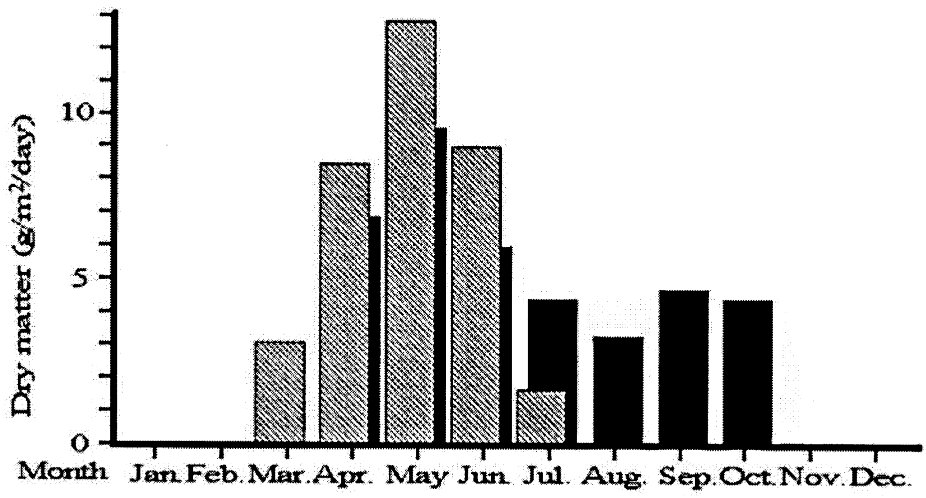

Figure 2
Summer depression area (painted) in the present and in the future.