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## Research into Turf Management Systems for Golf Courses

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### Abstract

It seems to be that turf management on a golf course is consisted of retarding of growth. This research intends to examine the turf management from the perspective of seasonal changes based on turf management data collected from 53 golf courses in Hyogo Prefecture over the five-years from 1982 to 1986 and to identify the management characteristics and their relationship to climatic conditions.

Turf management can be said to have two sides; promoting growth with fertilizer and retarding growth by mowing. A good balance between these two sides will result in the maintenance of a fresh, uniform turf.

This research makes clear that climatic conditions have a large effect on turf growth. Therefore, it is very important to analyze local climatic conditions in order to forecast and deal with outbreaks of disease, harmful insects, and weeds.

### Research Goal

It is no exaggeration to say that turf management on a golf course consists mainly of retarding various kinds of growth, including that of the turf itself. Grasping the proper response to turf growth is of crucial importance. The research described in this paper is based on turf management data collected from 53 golf courses in Hyogo Prefecture over the five-year period from 1982 to 1986. Turf management is examined from the perspective of seasonal changes, with the goal of identifying special management characteristics and their relationship to climatic conditions.

### Method of Investigation and Analysis

#### 1) Selection of Subject Golf Courses

All golf courses covered by this research were planted with *Zoysia matrella* turf. Golf courses were classified according to Masatoshi Yoshino's climatic regions as having either an Inland Sea Region climate or an Interior Region climate (Figure 1). Forty-nine of the subject golf courses had an Inland Sea Region climate, while 13 had an Interior Region climate. Figure 2 shows mean temperatures for each month in the two climatic regions. The mean temperature in the Inland Sea Region is at least 1°C higher than in the Interior Region every month of the year except May, and the annual mean temperature of the Inland Sea Region is, at 14.3°C, higher than the Interior Region's 12.9°C. Figure 2 also shows the mean amount of precipitation for each month in the two climatic regions. The amount of precipitation is higher throughout the year in the Interior Region, where the annual total is 1,600 mm, than in the Inland Sea Region, where the annual total is

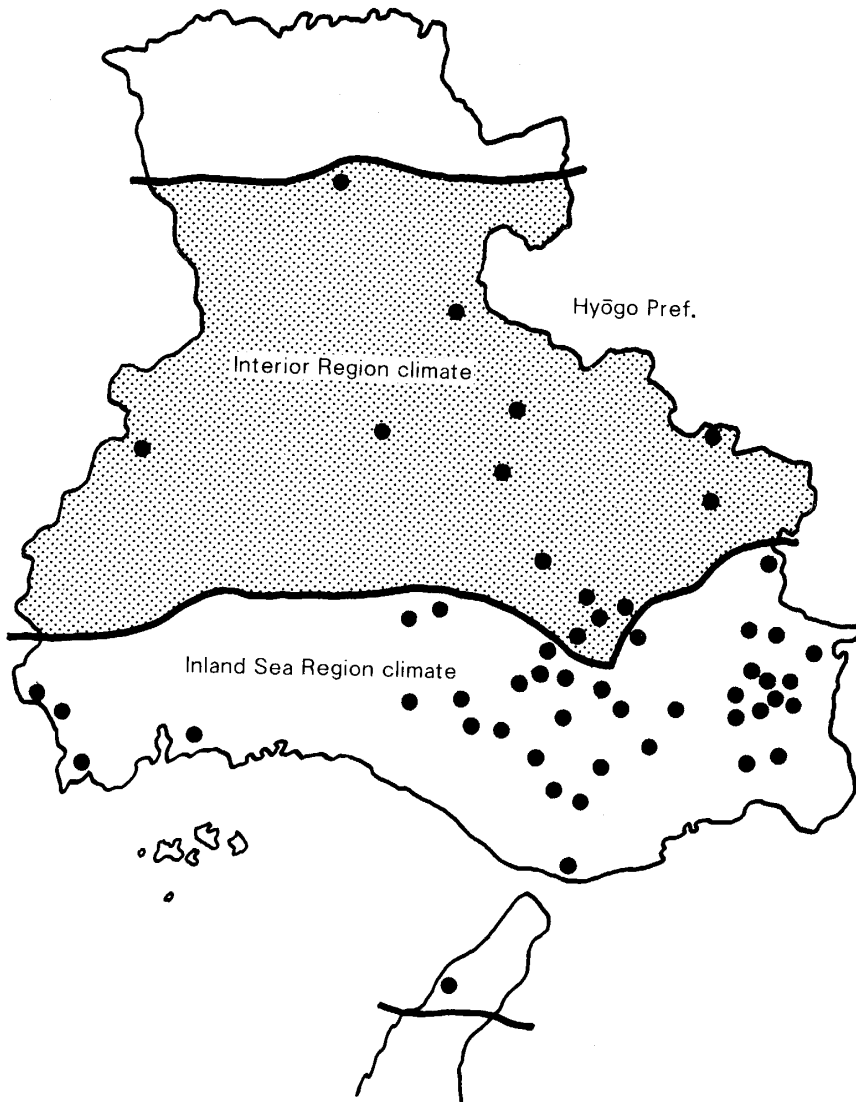


Fig. 1 Location of golf courses

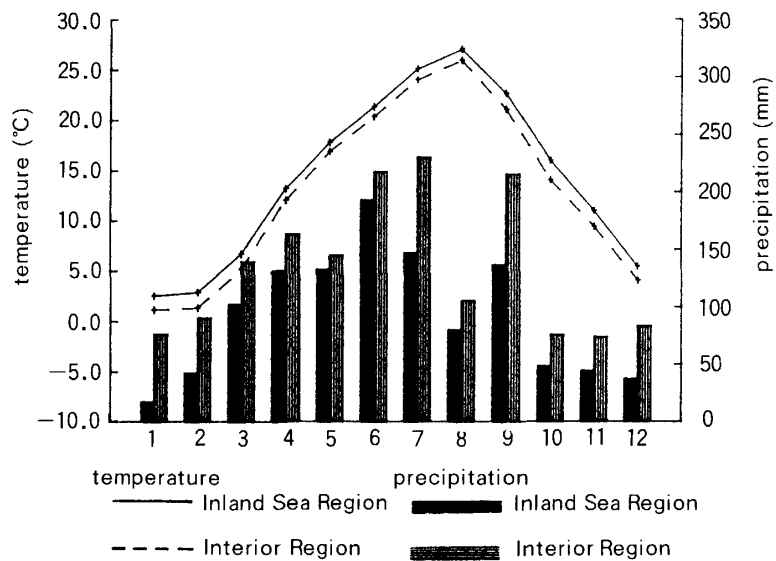


Fig. 2 Mean temperature and mean amount of precipitation for each month

Table 1 Turf management

(1) Maintenance	① Mowing	.....	(the mean number of times each month )
	② Watering	.....	(the mean number of times each month )
	③ Top Dressing	.....	(the mean number of times each month )
	④ Renovation	a) Airing	.....
b) Verticutting		..	(the mean number of times each month )
c) Slicing		.....	(the mean number of times each month )
d) Sweeping		.....	(the mean number of times each month )
(2) Fertilizing	① Nitrogen	.....	(the amount of Nitrogen applied each month )
	② Phosphorus	.....	(the amount of Phosphorus applied each month )
	③ Potassium	.....	(the amount of Potassium applied each month )
(3) Disinfection	① Sterilizers	.....	(the number of Sterilizers each month )
	② Insecticides	.....	(the number of Insecticides each month )
	③ Herbicides	.....	(the number of Herbicides each month )

1,100 mm. These data indicate that the Inland Sea Region has a generally drier and warmer climate than the Interior. Special characteristics of turf management systems were compared and considered with regard to these climatic differences.

2) *Characteristics of Maintenance*

As shown in Table 1, turf management can be divided into three categories: maintenance, fertilizing, and disinfection. Maintenance was analyzed by calculating the mean number of times each month that the following types of work were carried out: mowing, watering, top dressing, and renovation (airing, verticutting, slicing, and sweeping).

3) *Characteristics of Fertilizing*

Fertilizer is said to have three main elements: nitrogen, phosphorus, and potassium. Fertilizing was analyzed by calculating the mean amount of each element that was applied to golf course turf each month.

4) *Characteristics of Disinfection*

Disinfection was analyzed by calculation the number of sterilizers, insecticides, and herbicides use on golf course turf each month.

5) *Correlations Between Categories of Turf Management*

An analysis of the correlation between mowing and nitrogen fertilizer application was carried out.

It may be useful at this point to explain the processes of top dressing and renovation (airing, verticutting, slicing, and sweeping). In Photo 1, top dressing is being carried out. Top dressing means thinly sprinkling the surface of the turf with sand in order to untangle thatch and create a uniform finish. Photo 2 shows turf being aired with a greensayer. Airing means piercing holes through the turf and into the soil below for the purpose of providing oxygen to root systems, which promotes turf growth. Photo 3 shows a multipurpose machine used for verticutting, slicing, and sweeping. Verticutting and slicing are carried out by attaching a vertical blade that cuts into the turf. Verticutting and slicing are essentially the same work, except that the former cuts deeper into the turf and causes more damage. The purpose of both is to remove thatch and thin the turf.



Photo 1 Top dressing



Photo 2 Greensayer



Photo 3 A multipurpose machine used for verticutting, slicing, and sweeping

Sweeping can be carried out by attaching a brush to the same machine. Sweeping cleans the surface of the turf and eliminates thatch.

### Results of Analysis and Consideration

#### 1) Maintenance

Putting green maintenance and fairway maintenance were both analyzed in the course of this research, but here the topic will be limited to the putting green. Figure 3 shows the mean number of times turf was mowed each month, with the solid line indicating the mean value for Inland Sea Region golf courses, and the dotted line indicating the mean value for Interior Region golf courses. Mowing was carried out most often in July and August, when turf grows most vigorously. August in the Interior Region saw the most frequent mowing activity; 21 times in one month. Overall, turf was mowed more frequently in the Inland Sea Region, probably because the somewhat warmer climate there promotes turf growth. Inadequate precipitation is the most likely explanation for Inland Sea Region golf courses mowing their turf fewer times in August than Interior Region golf courses. In August, the Inland Sea Region receives only 80 mm of precipitation, an amount so small that it inhibits turf growth. Watering data are shown in Figure 4. August is the peak month for watering. In the Inland Sea Region, watering was carried out 8.5 times in August. Over the whole year, golf course turf was watered more often in the Inland Sea Region, where soil dries out quicker because of the higher temperature and

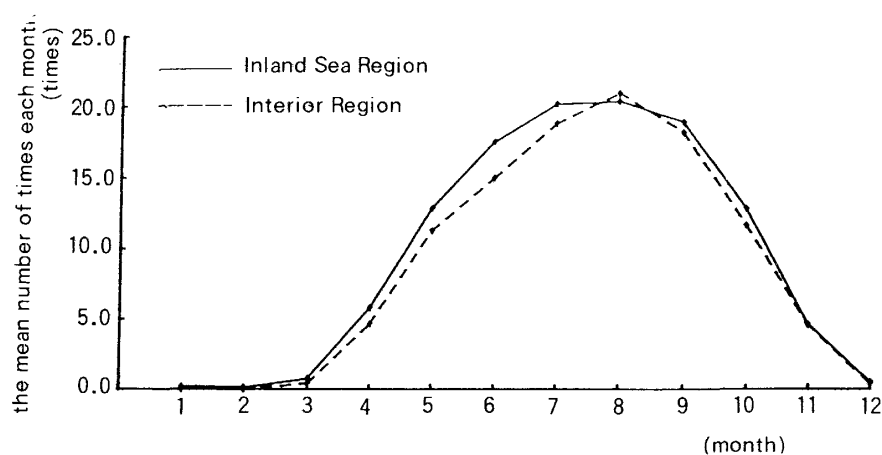


Fig. 3 The mean number of mowing each month

lower amount of precipitation. Figure 5 shows data for top dressing. The peak season for top dressing lasts from April to September, with the most frequent activity carried out in May and September. The mean number of times top dressing was carried out in the Inland Sea Region was 0.82 times in May and 0.62 times in September. A strong correlation was found between top dressing and the renovation work of airing. Figure 6 shows

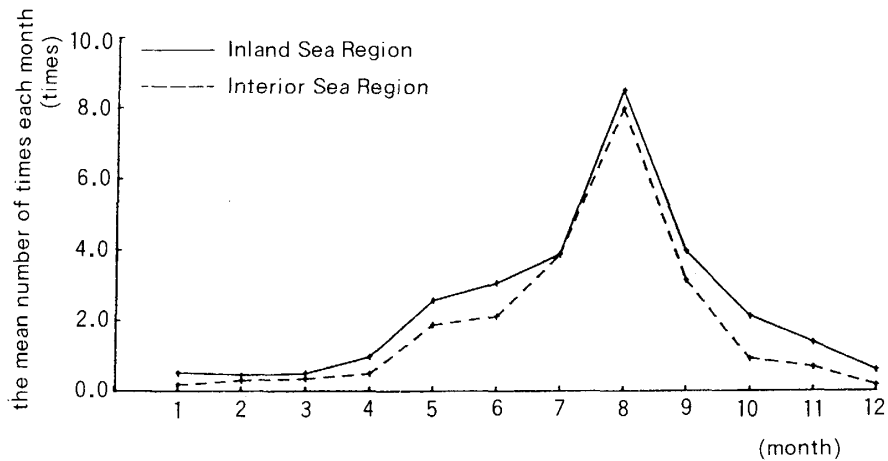


Fig. 4 The mean number of watering each month

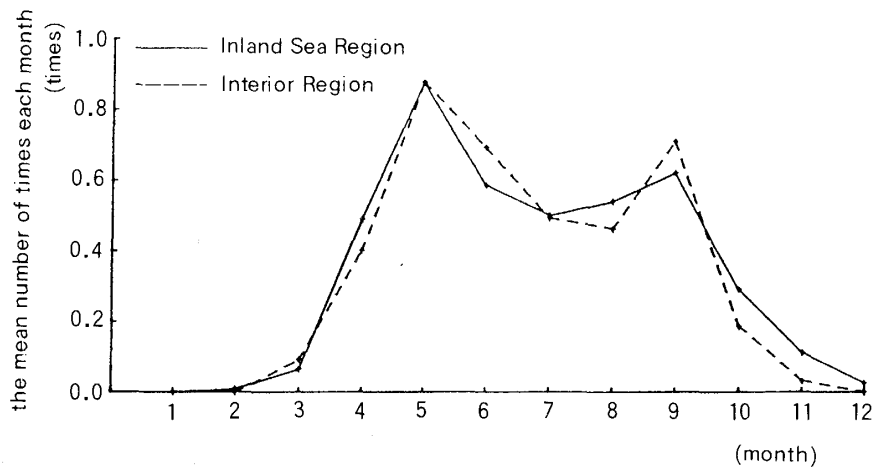


Fig. 5 The mean number of top dressing each month

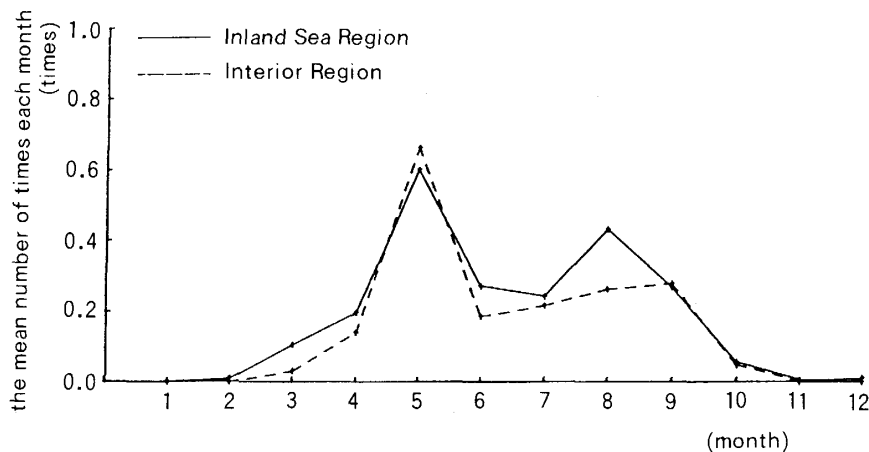


Fig. 6 The mean number of airing each month

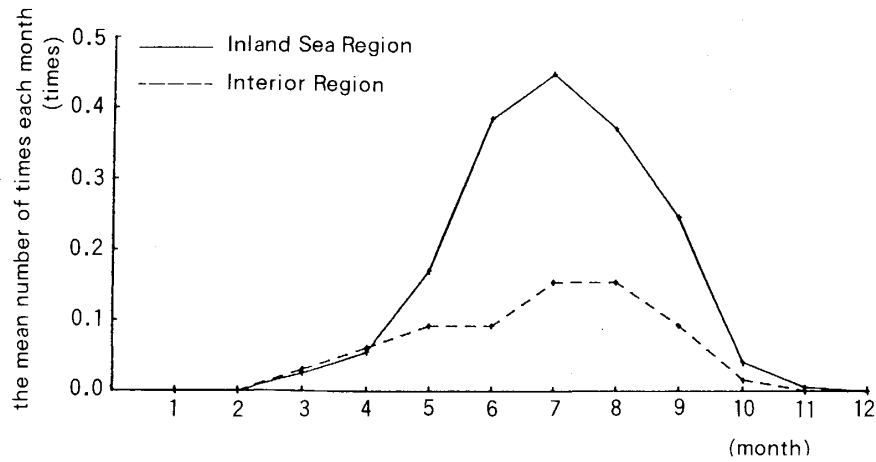


Fig. 7 The mean number of verticutting each month

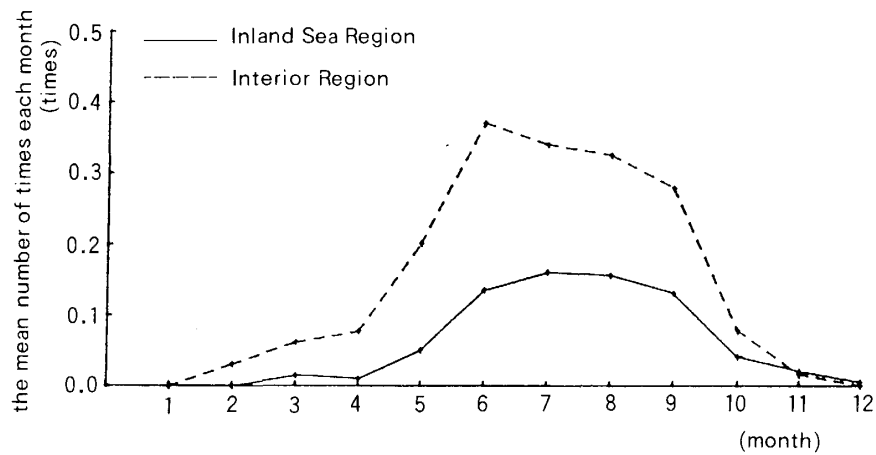


Fig. 8 The mean number of slicing each month

data on the four kinds of renovation work. Between the months of October and March, when turf is growing slowly or not at all, airing activity also comes to a near standstill. Airing is carried out most often in May, August and September. In May, turf is just moving into its high-growth period, so airing at this time promotes root growth. In August and September, airing promotes new root growth and the accumulation of reserve nourishment for fall. Some soil is extracted from turf in the airing process. In the months when airing is most common, top dressing is carried out frequently to compensate for the lost plugs of soil. Since airing does a considerable amount of damage to turf, it is generally carried out more often in the Inland Sea Region, where conditions for turf growth are better than in the Interior Region. Figure 7 shows data on verticutting. Verticutting is carried out primarily in the summer months, and considerably more often in the Inland Sea Region than in the Interior Region. In July, the peak month for this activity, verticutting was carried out an average of 0.45 times in the Inland Sea Region and 0.15 times in the Interior Region. As shown in Figure 8, slicing can also be described as a summertime activity, but slicing is more common in the Interior Region than in the Inland Sea Region. The purpose of both verticutting and slicing is to remove thatch, the main difference being that slicing accomplishes this task less efficiently and with less damage to turf than verticutting. Therefore, it can be said that slicing is better suited to the Interior Region, where the mean temperature is lower and consequently turf recovers from damage more slowly. Unlike other renovation work, sweeping is carried out

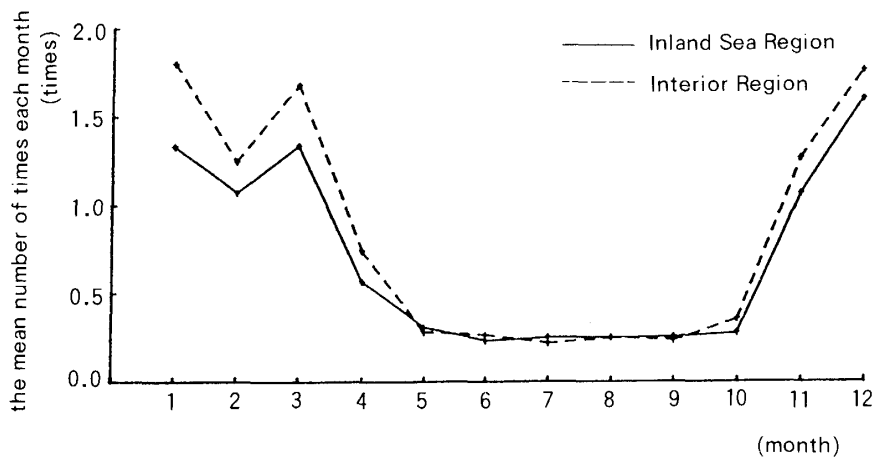


Fig. 9 The mean number of sweeping each month

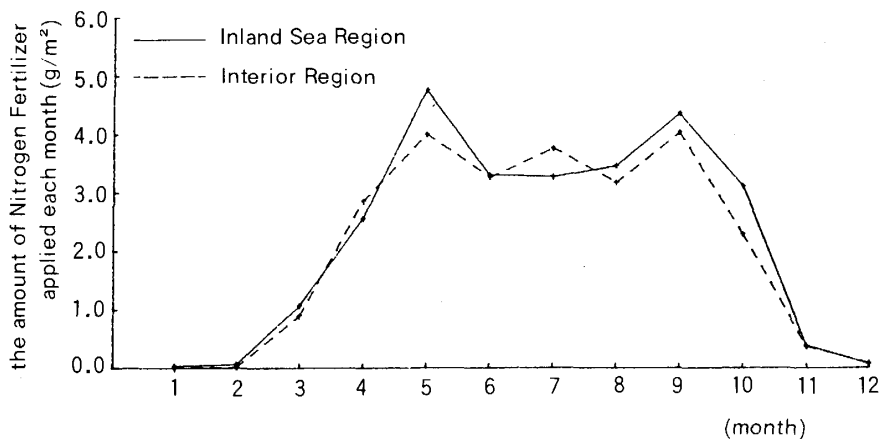


Fig. 10 The amount of nitrogen fertilizer applied each month

primarily in the months from November to March (Figure 9). One of the purposes of sweeping is to remove thatch. Since sweeping does not damage turf, it can be carried out even during the winter resting period, when verticutting and slicing would be ill-advised.

## 2) Fertilizing

Figure 10 shows the mean amount of nitrogen applied each month in the two climatic regions. Nitrogen is applied relatively often during the growth period of turf, which lasts from April to October, and infrequently or not at all during the resting period from December to February. Nitrogen application is heaviest in May and September, reaching 4.75 g/m<sup>2</sup> and 4.34 g/m<sup>2</sup> respectively in the Inland Sea Region. The amount of application is large in May because that month immediately precedes rainy season and marks the beginning of turf's high growth period. Heavy application of nitrogen in September is intended to increase the stored nourishment supply for turf in the next year's emerging period of March and April. Nourishment stored in creeping roots during the previous year is the main source of energy for turf in its emerging period. Application of phosphorus and potassium follow the same pattern as nitrogen. A comparison of application amounts in the two climatic regions shows that larger amounts of all three fertilizer elements are applied in the Inland Sea Region.



### 3) Disinfection

Figure 11 shows the mean number of sterilizers used each month in the two climatic regions. Sterilizers are applied virtually every month, with peaks in April, July, and September/October. This pattern of application indicates the months in which damage by disease is most likely to occur. It can be surmised that damage by *Helminthosporium* is common during the summer rainy season, while spring dead spots and shizumi are seen more often in the spring and fall. Figure 12 shows data on insecticides. Insecticides are scarcely applied at all from November to March, but are widely used in July and August to combat the outbreaks of harmful insects that occur in the summer. The number of sterilizers and insecticides applied in the Inland Sea Region was greater than in the Interior Region, probably because conditions for turf-damaging diseases and insects are more favorable in the Inland Sea Region. Patterns of herbicide use are shown in Figure 13. Even in September, the month of maximum herbicide application in the Inland Sea Region, the number of varieties applied to the putting green was only 0.05. Putting greens are subject to such extremely close mowing that many species of weeds cannot survive. In other words, weed control on the putting green is largely carried out by physiological rather than chemical means.

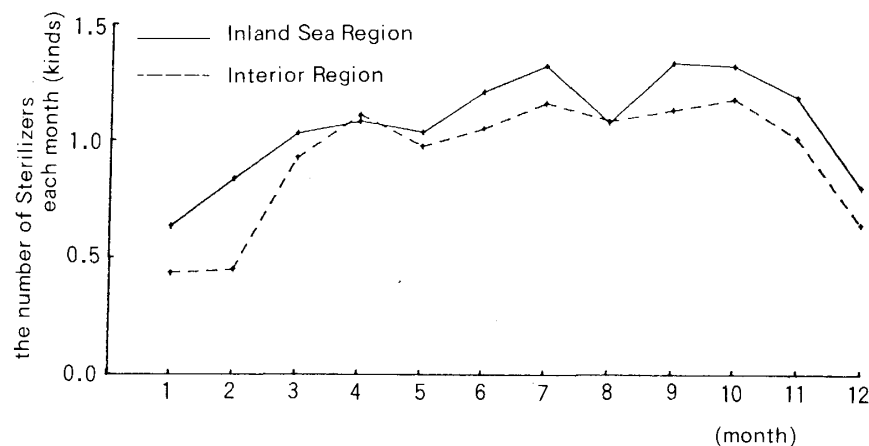


Fig. 11 The number of sterilizers each month

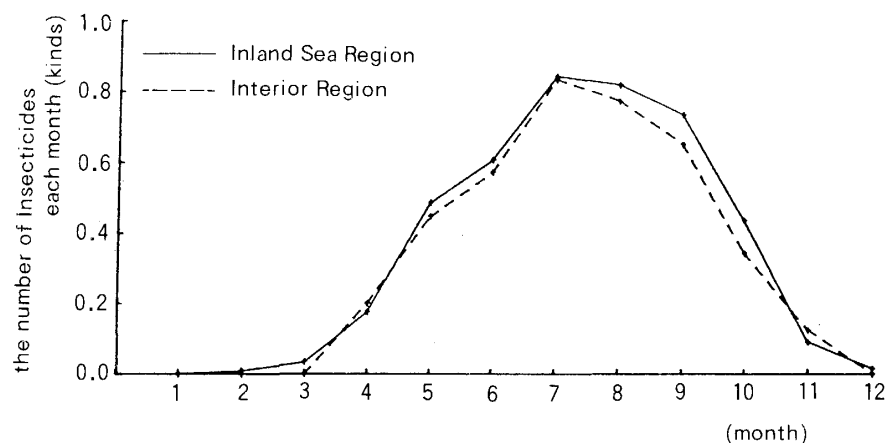


Fig. 12 The number of insecticides each month

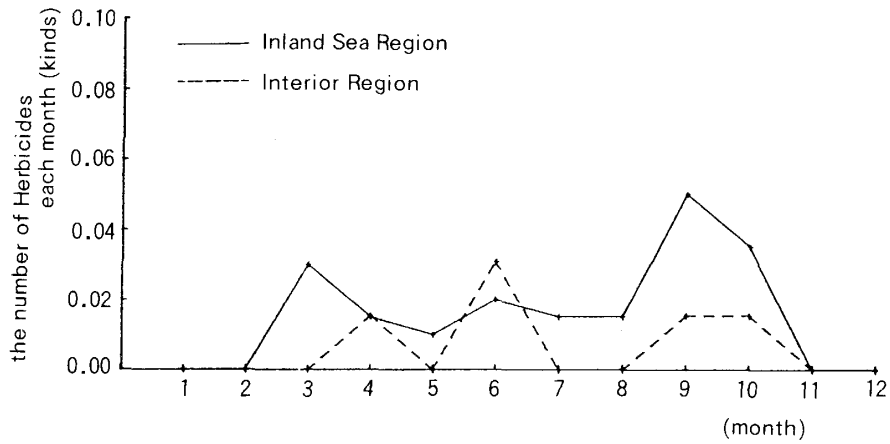


Fig. 13 The number of herbicides each month

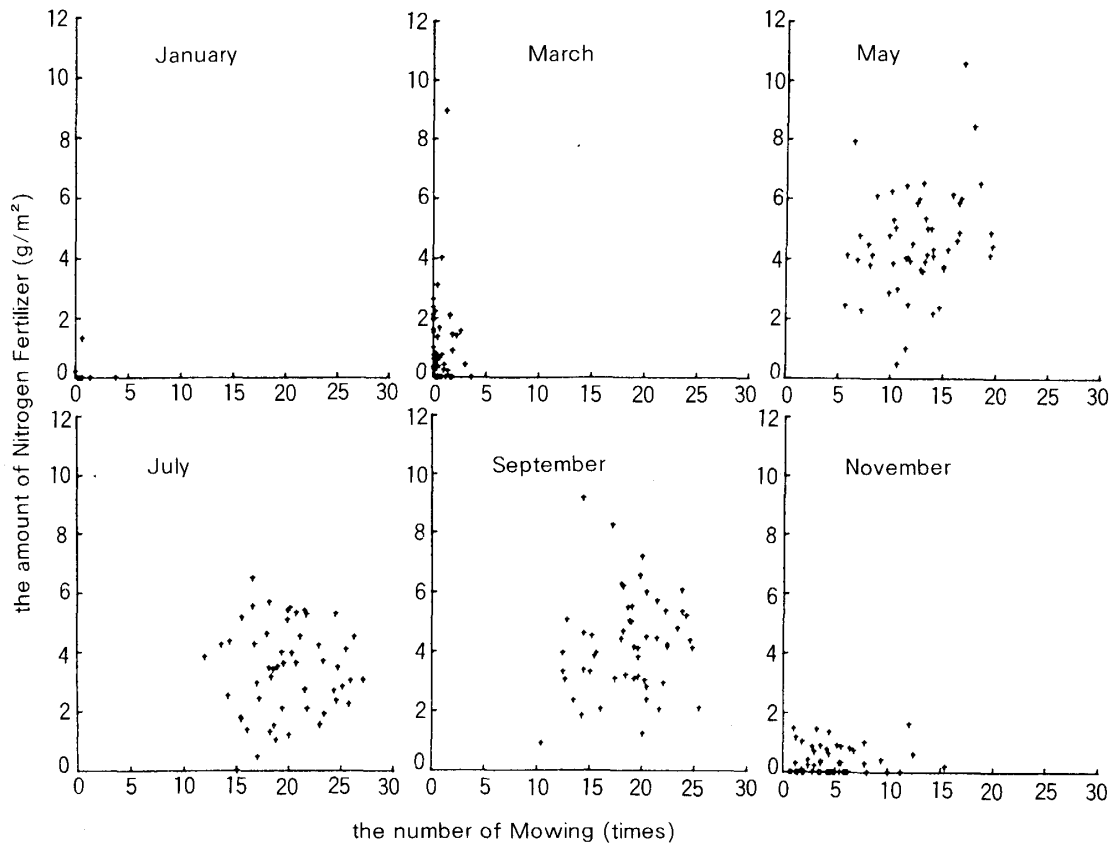


Fig. 14 The relationship between mowing and nitrogen fertilizer

4) *The Relationship Between Mowing and Nitrogen Fertilizer*

Figure 14 shows the correlation at each golf course between the number of times mowing was carried out and the amount of nitrogen fertilizer applied in January, March, May, July, September, and November. Viewed in this way, the relationship between fertilizer application and mowing becomes clear over a one-year time cycle. Owing to the fact that turf is in its resting period in January, almost no mowing or fertilizing were carried out in this month. March is turf's emerging period, so there is little if any growth, and almost no mowing activity. In May, the beginning of the high-growth period of turf,

mowing is carried out from 10 to 15 times, while the amount of nitrogen applied increases to 4–6 g/m<sup>2</sup>. Turf growth falls off in November, and mowing and fertilizing decline correspondingly. The amount of nitrogen fertilizer applied in November is particularly low. These data indicate that there is a correlation between amount of nitrogen fertilizer applied and number of times mowing was carried out. In other words, turf management can be said to have two sides; promoting growth with fertilizer and retarding growth by mowing. A good balance between these two sides will result in the maintenance of a fresh, uniform turf.

### Conclusion

This research makes clear that climatic conditions have a large effect on turf growth. Therefore, it is very important to understand local climatic conditions in order to forecast and deal with outbreaks of disease, harmful insects, and weeds.

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