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<th>その他の（別言語等）のタイトル</th>
<th>水稲における葯中の花粉粒数</th>
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<td>Sawada Souhei, Saka Seiko</td>
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The Number of Pollen Grains in Rice Plants

Souhei SAWADA and Seiko SAKA

(Laboratory of Forage Crops, Obihiro Zootechnical University, Obihiro, Hokkaido, Japan)

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水稲における葦中の花粉粒数

沢田壮兵* · 阪 正光*

Introduction

In rice plants unfertilized spikelets are induced by low temperature during the booting stage. The degree of occurrence is known as “cool tolerance”, which is an important agronomic character in rice cultivation in northern Japan. Cool tolerance is known to differ among varieties. The factors which cause varietal difference of cool tolerance are considered to be as follows: 1. the number of pollen grains produced in anther, 2. the degree of immature pollen induced by low temperature, 3. the ability of anther dehiscence, 4. relations between the number of mature pollen grains on stigma and fertilizing. The mechanisms by which pollen grains lose their function have been studied, but investigations which deal with the other factors are scarce, especially no observations have yet been made on the number of pollen grains produced in rice plants.

It is the object of this paper to show the number of pollen grains produced by rice plants and the effect of low temperature during the booting stage.

The authors wish to express their gratitude to Dr. T. NARIKAWA and his colleagues for the use of facilities of the Hokkaido-Tokachi Pref. Agr. Exp. Sta.

Materials and Methods

Materials used and their heading date are showed in Table 1 with sterility percentage. Hayayuki, Shiohari and Norin 20 are varieties cultivated in Hokkaido and N. 4 is a linkage tester for gene analysis. The experiment was conducted in 1970. On April 25, seeds of four varieties were sown and the seedlings were transplanted on May 28 into pots (37×27×14 cm) made of polyvinyl.

The materials were grown in a green house and subjected to cool treatment during the booting stage. The method employed for cooling was essentially
the same as that described in a previous paper (SAWADA 1971). Treatment 1 (T1) was made from July 16 and Treatment 2 (T2) from July 23 for 5 days respectively.

One plot consisted of three panicles and ten spikelets were taken from one panicle. The numbers of pollens were counted one by one on six anthers in a spikelet under microscope. 1N–HCl was used as the macerating fluid. The pollens which were well stained by aceto-carmine were counted as functional.

Results

1. The number of pollen grains in a spikelet

Total number of pollen grains of six anthers in a spikelet are shown in Fig. 1.

![Number of pollen grains per spikelet](image)

The numbers are the mean of 30 spikelets from three panicles. In the control group, Hayayuki had about 5300 pollen grains to a spikelet and Shiokari, Norin 20 and N. 4 had 5900, 5000 and 6500 respectively. Namely, these varieties seem to produce about 1000 pollen grains per anther. N. 4 produced the largest number of pollen grains among the four varieties but no significant difference among them was seen (Table 2). This seems to suggest that the variation between inter-panicles were large.

Fig. 1 illustrates the effect of low temperature during the booting stage especially at the meiotic stage of pollen mother cells. In treatment 2 which was made 12–19 days before heading, the number of pollen grains decreased in
Table 2  Analysis of variance of pollen number in control

<table>
<thead>
<tr>
<th>Variation</th>
<th>Degree of freedom</th>
<th>Mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety</td>
<td>3</td>
<td>1238959</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>7</td>
<td>4229189</td>
<td></td>
</tr>
</tbody>
</table>

all varieties. The number of pollen grains in Hayayuki showed a decrease of 68% against the control, Shiokari 51% and Norin 20 46%. But N.4 showed a decrease of only 18% of the control. This fact seems to indicate that there are some differences among varieties in the reduction of the number of pollen grains by cooling during the booting stage.

Table 3 illustrates the analysis of variance of pollen number between varieties and treatments. There was significant difference in pollen number between varieties at a 5% level and between the treatment at a 1% level.

Table 3  Analysis of variance of pollen number

<table>
<thead>
<tr>
<th>Variation</th>
<th>Degree of freedom</th>
<th>Mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety</td>
<td>3</td>
<td>3742856</td>
<td>6.816*</td>
</tr>
<tr>
<td>Treatment</td>
<td>2</td>
<td>9965745</td>
<td>18.147**</td>
</tr>
<tr>
<td>Error</td>
<td>6</td>
<td>549160</td>
<td></td>
</tr>
</tbody>
</table>

*, **: Significant at a 5% and 1% level respectively.

2. Intra-panicle variation in the number of pollen grains per spikelet

Materials used in this experiment produced 70 to 100 spikelets in a panicle. Of these ten spikelets were measured. Intra-panicle or inter-ten-spikelets variation are as illustrated in Table 4.

Table 4  Intra-panicle variation in pollen number per spikelet (coefficient of variability %)

<table>
<thead>
<tr>
<th></th>
<th>Hayayuki</th>
<th>Shiokari</th>
<th>Norin 20</th>
<th>N.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>21.8</td>
<td>19.7</td>
<td>20.4</td>
<td>18.8</td>
</tr>
<tr>
<td>Treatment 1</td>
<td>23.7</td>
<td>10.2</td>
<td>29.7</td>
<td>11.7</td>
</tr>
<tr>
<td>Treatment 2</td>
<td>67.0</td>
<td>65.6</td>
<td>127.3</td>
<td>33.0</td>
</tr>
</tbody>
</table>

The coefficient of variability for the control of each varieties was about 20%. In Treatment 1, the value was the same in control. But, in Treatment 2, Hayayuki and Shiokari showed 3 fold values of the control while Norin 20 showed 5 fold values of the control.

As shown by an example of Norin 20 (Table 5), the panicle in which the coefficient of variability was 278.4% had spikelets with no pollen grains and nine spikelets showed a count below 1000 pollen grains.
Table 5  Examples of pollen number in Norin 20

<table>
<thead>
<tr>
<th></th>
<th>C. V. 9.7%</th>
<th>C. V. 22.3%</th>
<th>C. V. 43.2%</th>
<th>C. V. 278.4%</th>
</tr>
</thead>
<tbody>
<tr>
<td>4386</td>
<td>2873</td>
<td>1906</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4731</td>
<td>3386</td>
<td>2143</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5423</td>
<td>3419</td>
<td>2217</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5665</td>
<td>3658</td>
<td>2568</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5683</td>
<td>4075</td>
<td>3237</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>5819</td>
<td>4696</td>
<td>3897</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>5851</td>
<td>4713</td>
<td>4975</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>5854</td>
<td>5100</td>
<td>5177</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>5873</td>
<td>5363</td>
<td>6064</td>
<td>306</td>
<td></td>
</tr>
<tr>
<td>5930</td>
<td>5752</td>
<td>6175</td>
<td>4104</td>
<td></td>
</tr>
</tbody>
</table>

These results seem to suggest that intra-panicle variations grow larger by cooling treatment at 12-19 days before heading as compared with that of the control.

3. Intra-spikelet variation in the number of pollen grains

Variations within six anthers are as shown in Fig. 2. The horizontal line in the histogram indicates the coefficient of variability among six anthers and the vertical line shows the frequency of spikelets.

Fig. 2. Frequency distribution of coefficient of variability of pollen number among six anthers
the vertical line indicates the number of spikelets
the horizontal line indicates coefficient of variability
→ | ← indicates the average of 30 measurements

In the control, the coefficient of variability of three varieties, Hayayuki, Shiokari and Norin 20 were equally about 20%, except that N. 4 was less than the others. This value was the same as that of intra-panicle variation. Almost
no difference was seen between the control and Treatment 1, while in Treatment 2 they were two times as many as in the control of all varieties.

This trend in which variations became larger by cooling is the same as seen in intra-panicle variation.

4. Pollen fertility and variation among six anthers

Pollen fertility and pollen number were measured using five spikelets of each variety. The results obtained are as shown in Table 6. The table clearly indicates that the coefficient of variability of pollen fertility among six anthers in a spikelet are very small in the control, but this value became considerably larger as the pollen fertility decreased by cooling treatment.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Hayayuki (%)</th>
<th>Shiokari (%)</th>
<th>Norin 20 (%)</th>
<th>N. 4 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>93</td>
<td>4.2</td>
<td>78</td>
<td>8.5</td>
</tr>
<tr>
<td>Treatment 1</td>
<td>98</td>
<td>4.8</td>
<td>92</td>
<td>5.3</td>
</tr>
<tr>
<td>Treatment 2</td>
<td>55</td>
<td>54.5</td>
<td>58</td>
<td>41.0</td>
</tr>
</tbody>
</table>

It is likely that the variations among varieties tend to be enlarged by the cooling treatment. But it is not evident as to why Hayayuki and Shiokari which are resistant to low temperature showed a larger variation by cooling than Norin 20 and N. 4 which are sensitive.

5. Relations between the number and fertility of pollen grains

From the above description, it is clear that by cool treatment at 12–19 days before heading the number and fertility of pollen grains decreased and

Fig. 3. Relations between pollen number and pollen fertility

**: Significant at a 1% level.
intra- and inter-spikelet variation increased. Next the relations between the number and fertility of pollen grains are illustrated in Fig. 3. The correlation coefficient between them was calculated to be $-0.775$, $-0.889$ and $-0.672$ of Hayayuki, Shiokari and Norin 20 respectively. These were significant at a 1% level. But N. 4 showed no significance.

These results suggest that the reduction of pollen numbers by cooling was accompanied with the lowering of pollen fertility in three varieties used except in N. 4.

Discussion

Reports on the pollen number of cultivated plants are scarce, in spite of many observations of the size, shape and other characters of pollen grains. Pohl (1937) studied the characters of pollen grains of anemophilous flower plant and counted the number of pollen grains. According to his observations the pollen numbers of corn (Zea mays) and rye (Secale cereale) were about 3400 and 19,000 in an anther, respectively. Beri and Anand (1971) counted the number of pollen grains per anther in 22 wheat varieties and found a variation from 581 to 2153 among of them. The results obtained in this experiment indicated that rice plants produce about 1000 pollen grains in an anther and suggest that rice plants which are self-pollinated produce less pollen grains than corn and rye cross-pollinated plants.

It may be suggested that there are some difference of pollen number among varieties of rice, although in this experiment the differences among four varieties were not statistically significant because of the large variation within panicles.

In studies on the cool weather damages of rice plants, the main effects of low temperature on plants during the booting stage have been considered to prevent the developing of micro-spores and loss of function of the anther. By these effects, the plants fail to carry out fertilization and may give rise to unfertilized spikelets. The results of the present study indicate that in addition to the above effects, the reduction of pollen number is induced by low temperature and that the reductions are in parallel with the lowering of pollen fertility. It is possible to assume that the two stages of microspore-genesis, namely the occurrence of pollen mother cell and tetrad, are more important to the pollen number. The decrease of pollen number in this experiment seems to correspond with the latter stage, inasmuch as the cooling treatment was made 12-19 days before heading. It may be suggested that the reduction of pollen number is not the direct cause by which spikelets become unfertilized but the particular cause which brought about pollen immaturity and anther indehiscence induced the reduction.

Summary

The present investigation was carried out to secure information on the
pollen numbers of rice plants and the effects of low temperature during the booting stage.

1. The four varieties used, namely Hayayuki, Shiokari, Norin 20 and N. 4, produced about 5000-7000 pollen grains in a spikelet. The conversion rate per anther is approximately 1000. Self-pollinateted rice plants produce a fairly small number of pollen grains than those of corn and rye, which are cross-pollinated plants and produce 3400 and 19,000 pollen grains respectively.

2. It may be assumed that there are some differences of pollen number among varieties. But in this experiment the differences were not significant statistically, because of the large variation among panicles.

3. The number of pollen grains showed a decrease of 1/3 to 1/2 of that of the control as a result of cooling treatment at 12-19 days before heading. While the intra-panicle variations (among ten spikelets) and spikelet variations (among six anthers) grew considerably larger by cooling.

4. Intra-spikelet variations of pollen fertility were small in the control and became enlarged by cool treatment.

5. It seems that rice plants are characterized by lower pollen fertility and a reduction in pollen number as induced by low temperature during the booting stage.

Literature cited


摘　要

水稻の花粉数を増やす花粉粒数と粒数が雑種期の低温によりどのように影響を受けかかるかについて実験を行なった。

1. 用いた4品種（はやゆき、しおかり、農林２０号およびN.４）は１穂花あたり5000～7000の花粉をつくり出している。

2. 花粉粒数には品種間の差があると考えられる。しかし、本実験では雑種の変異が大きく、統計的には有意とならなかった。

3. 出穂12～19日前に低温処理を行なうと花粉粒数は無処理区の1/3〜1/2に減少した。

また、1穂内（10穂花）および1穂花内（6穂間に）の花粉粒数の変異も低温処理を行なうことにより著しく大きくなった。

4. 1穂内（6穂間に）の花粉稔性の変異は無処理区で小さく低温処理区で大きくなった。

5. 水稲は雑種期に低温にあうと、花粉稔性の低下とともに花粉粒数も減少する。