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# Effect of *Barley Yellow Mosaic Virus* (BaYMV)- Infested Soil on the Agronomic Characters of Three Different Barley Varieties

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**ABSTRACT** *Barley Yellow Mosaic Virus* (BaYMV) caused significant reduction in barley yield and is difficult to control due to alive parasitic soil-borne fungus, *Palmyra gamines* that transmits the, virus. Previous studies have indicated that a virus-free soil could be infested by using virus-contaminated farming machineneries and implements. For the further confirmation of this finding, different proportions of BaYMV-infested soil were mixed into virus free soil. Three barley varieties (*Hordum vulgarae*, cv "Olbori", "Baegdong" and "Sacheon 6") were sown in pots treated with different rate of *P. graminis*-infested soil ranging from 0% to 100% in October 20, 2001. Results showed that BaYMV infection increased as the rate of infested soil increased. Initial symptoms were observed in a pots treated with 10% infested soil in all the 3 varieties of barley. "Olbori" had about 5% infection in 20% infested soil and about 10% infection in 40% or 50% infested soil and about 20% infection in 60% infested soil. In "Baegdong", the trend of BYMV occurrence was similar with "Olbori" but the time of severe infection was earlier than "Olbori". BaYMV infection in "Sacheon 6" was even earlier than "Baegdong" with much more severe symptoms than "Baegdong". The growth rate of barley was affected by about 19-22% when grown in 20% infested soil. As the rate of BaYMV infested soil increased the heading date was delayed but the maturing date was early in "Olbori" and "Sacheon 6". Also, reduction rate of culm length in 3 varieties increased with increase of infested soil content. However, "Olbori" showed the highest reduction. "Sacheon 6", have been characterized with long spike length, however was significantly reduced as the infested soil increased. On the other hand, spike length of "Olbori" was not significantly affected despite of increased of infested soil. The reduction rate of 1000 kernel weight was higher in large kernel size cultivar "Sacheon 6" and "Olbori" than small kernel size "Baegdong" as increase of BaYMV-infested soil content.

*Keywords* : BaYMV, infected soil, agronomic character, Culm

***Barley*** *Yellow Mosaic Virus* (BaYMV) is transmitted by soil borne fungal, *Polymyza graminis*, belonging to the *Plasmodiophorales* (Adams *et al*., 1986) which is alive parasitic and is difficult to be controled by chemical applications. The symptoms appear as yellow spot on young leaves and in advance stage it become yellow dwarf due to delayed growth and heading date and showed pin wheel inclusion body in infected cell (So *et al*., 1988). The experimental host range of BaYMV is limited to barley. The viral particle have flexuous filamentous particles of 2 lengths approximately 270-290 nm and 570-600 nm, 12-13 nm in width. The first BaYMV occurrence was reported in Germany in 1978 (Huth *et al*., 1984; Huth, 1988), England (Hill, 1985) and France (Signoret and Huth, 1991).

In Korea, the first report of BaYMV occurrence was in 1978 (RDA. Annual Report) and identified as 30 virus group (Lee, 1981). The mosaic symptom was further identified to be associated with viral particles (So.1988; 1990; 1991; 1993). Initial BaYMV occurrences were reported in Kyungsang, Jeonnam and Chungcheng provinces. Varieties that were susceptible to BYMV were "Baegdong" and "Youngsanbori" while "Hyangmaeg" and "Azumamugi" were resistant (Kim and Cheong, 1983).

Although, BaYMV had long been studied by many scientists, resistance mechanism is still need to be elucidated. In order to analyze the occurrence of the BaYMB, plant response to the increase of soil content that was infestation with BaYMV.

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## MATERIALS AND METHODS

Three barley varieties (*Hordum vulgarae*, cv Olbori, Baegdong and Sacheon 6) were sown at a rate of 5 seeds per pot in different ratio of BaYMV-infested soil ranging from 0% to 100%, in October 20, 2001. BaYMV infested soil that was obtained from NYAES field and sterilized soils (autoclaved at 120℃, 1.2 bar for 1.5 hrs, sieved twice with 2.0 mm sieve) was mixed for the soil preparation. Infection rate was observed at March 17th by a standard protocol of Rural Development Administration (RDA), 0 (no symptom), 1 (below 1% of infection rate in spikes), 3 (between 1% to 5% of infection rate in spikes), 5 (between 6% to 10% of infection rate in spikes), 7 (between 11% to 20% of infection rate in spikes), 9 (over 21% infection rate by spikes). The rate of growth was investigated based on culm length, spike length, grain number, and one thousand kernel weight. Fertilizer application was followed the standard of RDA, N-$P_2O_5$-$K_2O$ : 78-74-39/ha.

## RESULT AND DISCUSSION

### Infection rate at different percent of BaYMV – infested soil

The rate of infection according to the increase of infested soil from 0 to 100% was shown in Table 1. Symptom was started to appear in a pot with 10% infested soil mixture. Then degree of infection was scored 3 at 20% while 5 at 40% infested soil mixture in “Olbori” and “Baegdong”. The degree of infection also increased at 7 at 70% infested soil in “Olbori”. However, degree of infection in “Baegdong” reached 7 at 50% indicating that “Baegdong” is more susceptible than “Olbori”. On the other hand, “Sacheon 6” showed similar rate of infection trend with “Baedong” but comparatively more severe than “Baegdong” because infection of 7 for “Baegdong” was obtained even at 40% infested soil. These results support the yearly increment of BYMV infection in susceptible varieties in the infested farmer’s field. To avoid the spread of BaYMV infection, the farmer must wash the machine after cultivation in preventing the extent of contamination.

### The stage of growth by the additional soil infected with BaYMV

The mode of growth due to effect in increasing infested soil with BaYMV was shown in Table 2. It showed that with the increase of BaYMV infested soil, a delay in the heading date occurred however the maturing date was early in “Olbori” and “Sacheon 6”. In “Baegdong”, the maturing date was similar with above varieties but maturing period was more and less short. This result was similar with the work of So (1988) who reported that the growth of barley

**Table 1.** The rate of *Barley Yellow Mosaic Virus* infection based on the degree of infested soil

| Rate of infested soil (%) | Infection degree (0-9)† | | |
|---|---|---|---|
| | Olbori | Baegdong | Sacheon 6 |
| 0 | 0* | 0 | 0 |
| 10 | 1 | 1 | 1 |
| 20 | 3 | 3 | 3 |
| 30 | 3 | 5 | 5 |
| 40 | 5 | 5 | 7 |
| 50 | 5 | 7 | 7 |
| 60 | 7 | 7 | 7 |
| 70 | 7 | 9 | 7 |
| 80 | 7 | 9 | 9 |
| 90 | 9 | 9 | 9 |
| 100 | 9 | 9 | 9 |

†0: No symptom, 1: Below 1% of infection rate by spikes, 3: Between 1% to 5% of infection rate in spikes, 5 Between 6% to 10% of infection rate, 7: Between 11% to 20% of infection rate, 9: Over 21% infection rate.

**Table 2.** Heading and the maturing day of barley inoculated with BaYMV infected soils

| Character | Varieties | Rate of infested soil (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Heading day | Olbori | 4.3 | 4.4 | 4.6 | 4.4 | 4.6 | 4.7 | 4.8 | 4.9 | 4.9 | 4.10 | 4.10 |
| | Sacheon 6 | 3.29 | 3.30 | 4.1 | 3.31 | 4.3 | 3.31 | 3.30 | 3.31 | 4.2 | 4.2 | 4.1 |
| | Baegdong | 4.11 | 4.13 | 4.13 | 4.12 | 4.17 | 4.17 | 4.13 | 4.15 | 4.16 | 4.18 | 4.18 |
| Maturing day | Olbori | 5.9 | 5.10 | 5.9 | 5.10 | 5.11 | 5.10 | 5.11 | 5.11 | 5.11 | 5.11 | 5.12 |
| | Sacheon 6 | 5.7 | 5.7 | 5.7 | 5.7 | 5.6 | 5.6 | 5.5 | 5.5 | 5.4 | 5.5 | 5.5 |
| | Baegdong | 5.16 | 5.15 | 5.15 | 5.14 | 5.14 | 5.14 | 5.14 | 5.14 | 5.14 | 5.16 | 5.17 |

**Table 3.** Culm lengths of Barley plants gown in pots with different percent of of BaYMV-infested soil

| Character | Varieties | Percent infested soil (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Culm length | Olbori | 85 | 75 | 66 | 64 | 59 | 53 | 56 | 46 | 48 | 36 | 38 |
| | Sacheon 6 | 80 | 70 | 65 | 59 | 53 | 57 | 56 | 58 | 34 | 41 | 48 |
| | Baegdong | 80 | 72 | 63 | 54 | 43 | 48 | 43 | 38 | 35 | 28 | 40 |

**Fig. 1.** Barley plant growth in pots with different quantity of BaYMV- infested soil.

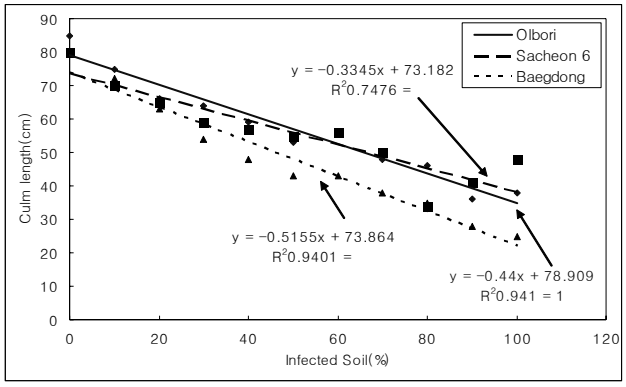


**Fig. 2.** The reduction of culm length as to increasing the infected soil with *Barley Yellow Mosaic Virus*es.

infected by BaYMV was delayed on heading date and early on maturing date.

As a result, BaYMV severely affecting the plant growth and resulted in delayed heading date while shortened maturity due to the insufficient nutrient supply.

The rate of culm reduction by increasing the infested soil content was shown in Table 3 and in Fig. 2. The culm length of "Olbori" variety covered barley in pot of virus-free soil was 85 cm. While at 20% ratio of infested soil, the culm length was 66 cm. resulting to 22% reduction in the culm length. However at 50% ratio of infested soil was used, the culm length was only 53 cm, which means a reduction of 48%. At 90% ratio of infested soil, culm length was reduced to 36 cm by which 68% reduction rate was attained. The analysis of $R^2$-regression were $y = -0.44\chi + 78.91$, $R^2 = 0.941$ indicating that an apparent reduction rate depends on the amount of infested soil with BaYMV.

The culm length of malting barley "Sacheon 6", was 80 cm in pot with non-infested soil but it was 65 cm in pot with 20% infested soil. Culm length was reduced by 19% than the pot with non-infested soil. However, increasing the infested soil mixture by 50% and 80%, culm length was 57 cm and 34 cm, having 29% and 57% reduction rate, respectively. The analysis of $R^2$-regression were $y = -0.33\chi + 73.18$,

$R^2 = 0.742$. This result indicates that apparent reduction rate depends on the amount of infested soil with BaYMV.

On the other hand, the culm length of naked barley, "Baegdong" gave 80 cm in pot with non-infested soil but was 63 cm in pot with 20% infested soil. Reduction was about 22% than the pot with non-infested soil and at 50% infested soil culm length was 48 cm, with 40% reduction. The analysis of $R^2$-regression were $y = -0.515\chi + 73.86$, $R^2 = 0.94$ indicating that apparent reduction rate depends on the amount of infested soil with BaYMV.

The reduction rate in culm length in 3 varieties (Olbori, Sacheon 6, Baegdong) as to increasing the infected soil was shown that "Olbori" showed the highest reduction.

Kim (1996) reported that the reduction rate of culm length due to BYMV infection at early stage of growth was reduced by 27~64% than those of healthy plants. Lee (2000) also reported that the culm length of resistant varieties were longer than those of susceptible varieties in Jinju and Naju field test.

The above result showed the culm length of susceptible varieties were reduced by 19~22% in pot with 20% infested soil and reduced by 40~48% in pot with 50% infested soil. This proved that the culm length was significantly reduced as the amount of the infested soil increased based on the $R^2$-regression analysis

The rate of spike reduction was dependent on infection rate as shown in Table 4 and in Fig. 3.

The spike length of covered barley, "Olbori" was 3.1 cm in pot with non-infested soil but it was 2.8 cm in pot with 20% infested soil. It was reduced by about 10% than the pot with non-infested soil. At 40% infested soil, spike length was reduced by 16% and at 70% infested soil, it was 2.0 cm with 35% reduction rate. The analysis of $R^2$-regression were $y = -0.005\chi + 3.04$, $R^2 = 0.302$. The non-significant difference indicated that the different percentage infested soil did not affect the spike length.

The spike length of malting barley, "Sacheon 6" was 5.7 cm in spot with non-infested soil, but was 5.5 cm in spot with 20% infected soil. It was reduced by about 4% than the pots with health soil. Adding 40% infected soil, the spike length was 4.5 cm and 16% in reduction rate. The $R^2 = 0.76$ indicated that apparent reduction rate of spike length with addition of infected soil with BaYMV.

The spike length of naked barley, "Baegdong" was 4.0

**Table 4.** Spikes lengths of Barley affected by the inoculation of soil infected with BaYMV

| Character | Varieties | Rate of infected soil (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Spike length | Olbori | 3.1 | 3.3 | 2.8 | 2.7 | 2.6 | 2.6 | 2.7 | 2.2 | 3.3 | 2.7 | 2.5 |
| | Sacheon 6 | 5.7 | 5.1 | 5.5 | 5.4 | 4.8 | 4.9 | 4.7 | 5.3 | 4.7 | 4.7 | 5.0 |
| | Baegdong | 4.0 | 3.8 | 3.4 | 3.1 | 2.1 | 3.0 | 2.0 | 2.1 | 3.0 | 2.4 | 3.1 |

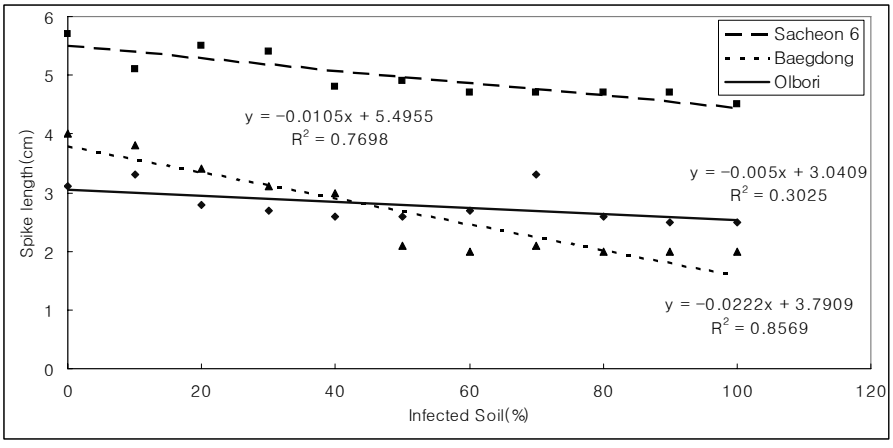


**Fig. 3.** Correlation between spike length and the soil infection rate used for the inoculation.

cm in pots with non-infested soil but was 3.4 cm in pots with 20% infected soil. It was reduced about 15% than the pots with health soil. At 40% infected soil, spike lenght was 2.1 cm, 47% in reduction rate. The analysis of $R^2$ showed apparent reduction rate of spike length depending on the addition of infected soil with BaYMV.

These results were different from the report that the reduction rate of spike length didn't affected by the incidence of BaYMV in Jinju and Naju regions (Lee *et al*., 2000). However, the result was in agreement with places in severely infected with BaYMV, e.g. the degree is above 7.

"Sacheon 6" that has long spike length showed more reduction in spike length as increase amount of infected soil, but "Olbori" did not showed significant difference. This might be ascribed by the short spike length of "Olbori"

The effects of the kernel numbers to BaYMV infection rate on infected soil was shown in Table 5 and Figure 4.

The kernel numbers of "Olbori", covered barley, was 40 kernels in pots with health soil but was 32 kernels in spot with 20% infected soil. It was reduced about 20% than that of the pots with health soil. At 50% infected soil, it was 29 kernels and showed about 27% in reduction rate. At 70% infected soil, it was 21 and 47% in reduction rate. The $R^2$ of 0.92 indicated that kernel number was highly related to the BaYMV infection.

The kernel numbers of "Sacheon 6" was 22 kernels in pots with health soil but was not changed in pots with 20% infected soil. At 50% infected soil, it was 19 and showed 14% reduction rate. At 70% infected soil, it was 18 and 14% reduction rate. The significant relationship between kernel number and added contaminated soil was found.

The kernel numbers of "Baegdong" was 54 kernels in pots with health soil but was 38 in pots with 20% infected soil. It was reduced about 30% than the pots with health soil. At 50% and 70% infected soils, kernel numbers were 37 and 22, respectively.

As the results, less reduction rate of kernel number in "Sacheon 6" may ascribed by less kernel numbers of malting barley. Kim (1996) and Lee (2000) reported the similar results that the kernel number was decrease when the barley infected with BaYMV.

Therefore, this study suggested that the field mixed 20

**Table 5.** Effect of Kernels number by the soil infected soil with BaYMV

| Character | Varieties | Rate of infected soil (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Kernel number | Olbori | 40 | 37 | 32 | 34 | 33 | 29 | 33 | 21 | 25 | 18 | 18 |
| | Sacheon 6 | 22 | 22 | 22 | 22 | 20 | 19 | 18 | 18 | 17 | 18 | 20 |
| | Baegdong | 54 | 26 | 38 | 42 | 24 | 37 | 25 | 22 | 23 | 13 | 23 |

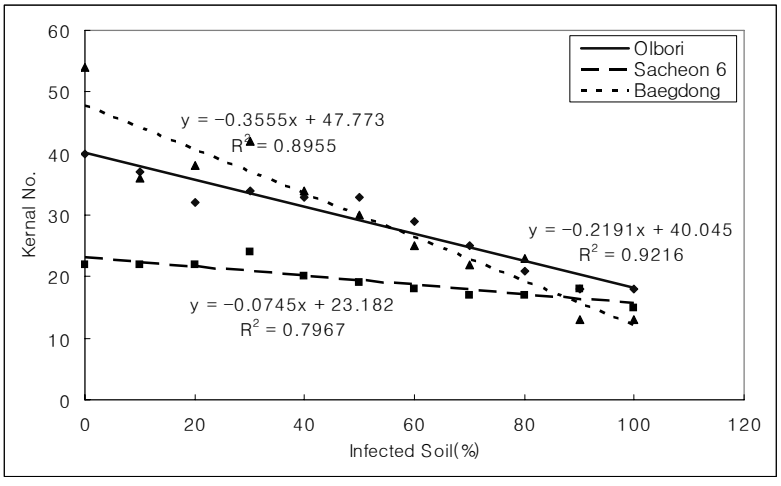


**Fig. 4.** The effects of the kernel numbers to BaYMV infection ratewith infected soil.

percent or more with infected soil with BaYMV affect directly the yield potential due to reducing kernel numbers.

The effects of BaYMV infection rate on 1000 kernel weight was shown in Table 6 and Figure 5. The 1000 kernel weight of "Olbori" was 33.4 g in pots with health soil but it was 29.8 g in pots with 20% infected soil. The one thousand kernel weight was reduced about 11% than that of the pots with health soil. At 40% infected soil, it was 27.7 g and showed 17% in reduction rate.

The 1000 kernel weight of "Sacheon 6" was 39.5 g in pots with health soil but was 35.3 g reduced in pots with 20% infected soil. It was reduced about 11% than the spot with health soil. At 60% infected soil, it was 34.0 g and showed 14% in reduction rate.

The 1000 kernel weights of "Baegdong" were 26.8 g in spot with health soil but it was 25.4 g in spot with 20% infected soil. It's reduced about 9% than the pots with health soil. At adding 70% infected soil it was 19.4 g, 28% in reduction rate.

As the results, the reduction rate of 1,000 kernel weight was high in "Sacheon 6" and "Olbori" which have large kernel size. The small grain size "Baegdong" showed relatively less reduction rate than "Sacheon 6" and "Olbori".

These results were similar with the previous reports (Huth *et al*., 1984) that the reduction of 1000 kernel weight of barley varieties were due to BaYMV-infested field. Also, this result was further supported by the result of Lee (2000) where reduction of 1000 kernel weight in the BaYMV infested barley in Jinju region.

Conclusively, at 10% infested soil was enough to induce BaYMV symptoms. At 20% infested soil, the culm length were reduced by 19~20%, and also the number of grain and a thousand weight was significantly reduced.

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**Table 6.** Effect of 1000 kernel weight to soil infected soil with BaYMV.

| Character | Varieties | Rate of infected soil (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| 1,000 kernel weight | Olbori | 33.4 | 31.4 | 29.8 | 28.2 | 27.7 | 29.0 | 28.2 | 27.4 | 28.0 | 27.2 | 25.8 |
| | Sacheon 6 | 39.5 | 36.4 | 35.3 | 35.6 | 36.0 | 36.3 | 34.0 | 37.0 | 28.6 | 28.5 | 27.5 |
| | Baegdong | 26.8 | 26.8 | 25.4 | 24.4 | 24.0 | 27.4 | 26.6 | 19.4 | 22.6 | 21.3 | 23.3 |

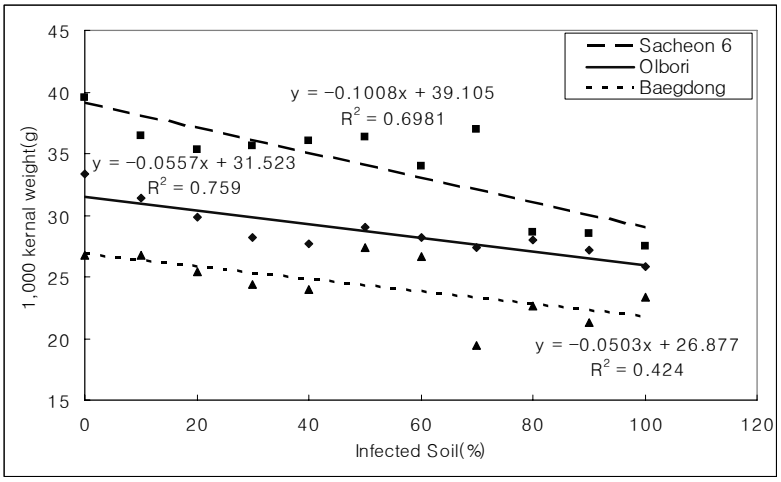


**Fig. 5.** Effects of inoculation of BaYMV infected soil on the 1000 kernel weight.

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