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# Progressive pattern of powdery mildew disease in sugar beet fields in Isfahan province

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## ABSTRACT

Sugar Beet production is of great importance in Isfahan province. Powdery mildew is a major limiting factor to sugar beet. To evaluate powdery mildew status in sugar beet fields, samples were collected from main sugar beet growing regions including Isfahan, Semirom, Faridan and Komeshcheh during 2009-10. In order to determine the disease severity, in each region, samples were taken at six growth stages from 10 fields. Disease severity was measured based on 0-100 scale. Results showed significant difference among fields in each location in relation to disease severity. The highest rate of disease was found in Isfahan and Semirom with 50.30 and 46.31%, respectively, whereas in Komeshcheh and Faridan it was 18.94 and 14.44%, respectively. In all studied regions, the disease progress began from early August and reached to its maximum level in the first week of September up to the first week of October in Isfahan. In Faridan, Semirom, and Komeshcheh, the maximum level was recorded in September, early September, and last week of September, respectively. The disease severity continued up to the last week of October in almost all regions. The sexual stage was observed as black points (cleistothecium) at the last stages of the growth. Microscopic studies confirmed the production of ascospores in the region.

**Keywords**: Cleistothecium, powdery mildew, sugar beet

## INTRODUCTION

Sugar beet (*Beta vulgaris*) is a biennial crop from Chenopodiaceae family which is planted as an annual crop (Mohammadi Gooltape et al. 1999). Based on FAO report, total sugar beet production in Iran was 3896820 t in 2010 (Anonymous 2010). Beet powdery mildew is one of the most common diseases in sugar beet production areas. Its damage to leaves results in reduction of root weight and sugar content (Ahmadinejad 1973). Rupple et al. (1975) reported about 6 t $ha^{-1}$ reduction in sugar beet yield in the USA. Asher and Williams (1992) reported about 3 ton root yield reduction with an average of 45 t $ha^{-1}$ in Europe. In Iran, because of proper environmental conditions and existence of multiple hosts, the disease has further developed and no chemical control is used against it (Behdad 2006). The disease affects all sugar beet production areas. The level of disease severity varies based on temperature and humidity changes. Powdery mildew is caused by *Erysiphe betae* fungus (class Ascomycetes, order Erysiphales, family Erysiphaceae). In Iran, powdery mildew is caused by *Erysiphe polygoni* DC. which is also called *Erysiphe betae* (Nasr Esfahani 2010; Behdad 2006). Sheykholeslami et al. (2005) reported that this disease only affects *Beta* species. However, other researchers identified it on Leguminoseae, Chenopodiaceae, and forage plant families and reported polyphaga fungus as a causal agent (Cock and Scott 1993; Schweizer 1983; Schweizer and May 1993). The disease is already developed in Iran (Behdad 2006). The fungus overwinters on sugar beet and

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**Table 1**. ANOVA results of powdery mildew severity in Isfahan city

| S.O.V. | df | Sum of squares | Mean squares | F | Pr > F |
|---|---|---|---|---|---|
| Year | 1 | 0.015 | 0.003 | 0.72 | 0.5785 |
| Replication (year) | 2 | 45.325 | 22.66 | 1.06 | 0.3483 |
| Fields | 9 | 9181.27 | 1020.14 | 47.90 | 0.0001 |
| Stages | 5 | 6245.87 | 1249.17 | 58.66 | 0.0001 |
| Year x fields | 9 | 1.2978 | 0.0180 | 3.46 | 0.0001 |
| Year x stages | 5 | 12.869 | 4.289 | 823.51 | 0.0001 |
| Fields x stages | 45 | 10500.41 | 233.34 | 10.96 | 0.0001 |
| Year x fields x stages | 45 | 0.629 | 0.209 | 10.28 | 0.0001 |
| Error | 263 | 2512.84 | 21.29 | | |
| Total | 359 | 28485.73 | | | |

Mean = 39.50 Root MSE 4.61 C.V. = 11.68 $R^2$=0.91

weed debris in the field and in, infects sugar beet late spring (Rapple et al. 1975; Drandarewski 1978). For further details about hosts, the reader is referred to Ershad (2009). The chemical control of the powdery mildew is not common in Isfahan province. Given the importance of the disease in Isfahan province, evaluating the current status of the disease in the province is inevitable.

## MATERIALS AND METHODS

In this study, sugar beet fields in Isfahan province were evaluated several times within two years (2009-10). Infected leaves were collected in winter and the sexual form of the fungus in terms of spore containing asci and ascospore was evaluated in the laboratory. In order to decrease experimental error and achieving appropriate results, a large population was used for statistical analysis. In total, 40 fields were visited regularly and the disease symptoms and severity were recorded. First sampling was performed mid-August and continued till mid-November. In cold and temperate regions, sampling was continued until early October and mid-November, respectively. From late March, in each of the cities (Faridan, Semirom, and Komeshcheh), 10 fields (labelled A to J) were visited every 10-15 days and in each field, 10 plants were selected randomly for powdery mildew evaluation. According to the National Institute of Agricultural Botany (UK) instruction, the disease severity was classified into six different indeices including 0, 10, 25, 50, 75, and 100 (Anonymous 1985). In order to determine the disease severity, separate evaluations were performed for each plant.

*Determination of disease severity*

Powdery mildew severity was assessed based on 6 subjective scale (Anonymous 1985) where, 0 = no lesion, 10 = lesions cover 10% of the leaves area, 25 = lesions cover 25% of the leaves area, 50 = lesions cover 50% of the leaves area, 75= lesions cover 75% of the leaves area, and 100 = lesions cover the whole leaves area.

Evaluations were performed separately for each stage in sugar beet production areas. Therefore, the disease severity percentage was estimated for different stages in each field, region and finally for all visited fields in the province (Anonymous 1985) by using the following equation:

$$\text{Disease severity} = \frac{\sum_{i=2}^{N} RiSi}{N} \times 100$$

where, $\sum_{i=1}^{N} Ri$ is the total plant number, Si is disease index which is 0, 5, 10, 25, 50, 75, and 100, and N is the total number of samples which was 10 in this study.

Data were analysed using randomized complete block design with three replications and mean comparison was performed by Duncan's multiple range test using SPSS and SAS software (SAS Institution 2004).

## RESULTS

Results showed that all fields were infected in the province and no chemical treatment was used.

*Isfahan*

At first stage (early August), the disease severity difference was significant ($p<0.05$) with minimum and maximum of 26.83 and 50.83%, respectively and average of 37.57% (Tables 1 and 2). At second (mid-October), fourth (late September), and fifth (late October) stages, the maximum severity was 44.83, 72.50, and 70.83%, respectively with the highest average (47.98%) observed at fifth stage (Table 2). At sixth stage, rainfall decreased the severity to 31.33% and a high correlation was observed in all fields (Table 2). Total

**Table 2**. Mean disease severity for different fields in Isfahan city

| | Disease severity at different stages | | | | | | |
|---|---|---|---|---|---|---|---|
| | First | Second | Third | Fourth | Fifth | Sixth | Total average |
| A | 50.66 c | 37.50 abcd | 41.33 cd | 72.50 e | 68.33 e | 31.50 a | 50.306 a |
| B | 50.83 c | 39.83 bcd | 38.66 bc | 63.33 d | 70.83 e | 34.16 a | 49.611 a |
| C | 26.83 a | 40.00 bcd | 48.50 d | 69.66 de | 70.33 e | 30.66 a | 47.667 a |
| D | 29.16 a | 43.00 d | 32.33 ab | 43.50 bc | 55.83 d | 28.50 a | 38.722 b |
| E | 36.66 ab | 41.33 cd | 41.83 cd | 45.83 bc | 41.33 bc | 33.16 a | 40.028 b |
| F | 44.66 bc | 44.83 d | 39.16 bc | 48.33 c | 30.66 a | 31.00 a | 39.778 b |
| G | 37.50 ab | 35.00 abc | 25.00 a | 40.16 b | 43.50 c | 30.66 a | 35.306 c |
| H | 31.83 a | 30.83 a | 32.50 ab | 29.50 a | 29.50 a | 32.16 a | 31.056 d |
| I | 35.50 ab | 32.66 ab | 30.66 a | 24.66 a | 33.83 ab | 32.50 a | 31.639 d |
| J | 32.16 a | 30.83 a | 30.00 a | 28.16 a | 35.66 abc | 29.00 a | 30.927 d |
| Mean | 37.57 | 37.58 | 35.99 | 46.56 | 47.98 | 31.33 | 39.508 |

Means with the same letter are not significantly different.

**Table 3**. ANOVA results of powdery mildew severity in Faridan city

| S.O.V. | df | Sum of squares | Mean squares | F | Pr > F |
|---|---|---|---|---|---|
| Year | 1 | 27.547 | 9.182 | 85.44 | 0.0001 |
| Replication (year) | 2 | 8.308 | 4.154 | 0.48 | 0.6229 |
| Fields | 9 | 1189.250 | 132.138 | 15.12 | 0.0001 |
| Stages | 5 | 0.210 | 0.052 | 0.49 | 0.7430 |
| Year x fields | 9 | 45.7701 | 0.6356 | 5.91 | 0.0001 |
| Year x stages | 5 | 1758.816 | 351.763 | 40.25 | 0.0001 |
| Fields x stages | 45 | 674.304 | 224.768 | 2091.35 | 0.0001 |
| Year x fields x stages | 45 | 1139.266 | 25.317 | 2.90 | 0.0001 |
| Error | 263 | 103.358 | 8.740 | | |
| Total | 359 | 5127.00 | | | |

Mean = 9.00 RootMSE 2.96 C.V. = 32.85 $R^2$=0.80

**Table 4**. Average disease severity for different fields in Faridan city

| | Mean comparison of disease severity at different stages | | | | | | |
|---|---|---|---|---|---|---|---|
| | First | Second | Third | Fourth | Fifth | Sixth | Total average |
| A | 9.33 b | 8.33 ab | 12.0 c | 9.66 b | 9.50 ad | 18.00 b | 11.22 b |
| B | 5.16 a | 8.00 ab | 9.33 ac | 9.16 b | 11.16 cd | 16.16 ab | 9.83 bc |
| C | 4.16 a | 10.66 bc | 11.33 bc | 6.83 ab | 10.50 bd | 26.66 c | 11.69 b |
| D | 5.83 ab | 13.33 c | 18.16 d | 8.66 ab | 11.83 d | 28.82 c | 14.44 a |
| E | 6.16 ab | 5.33 ab | 10.16 ac | 4.50 a | 9.50 ad | 12.83 ab | 8.08 cd |
| F | 2.50 | 6.50 ab | 11.66 bc | 8.16 ab | 7.16 ac | 11.83 ab | 9.77 cd |
| G | 4.16 a | 7.33 ab | 4.66 a | 6.16 ab | 7.16 ac | 11.66 ab | 6.86 d |
| H | 6.00 ab | 4.16 a | 6.33 ab | 6.16 ab | 6.66 ab | 9.16 a | 6.41 d |
| I | 3.00 ab | 7.83 ab | 6.50 ac | 7.16 ab | 5.66 a | 8.66 a | 6.47 d |
| J | 6.00 | 6.16 ab | 6.83 ac | 6.16 ab | 8.00 ad | 8.83 a | 7.00 d |
| Mean | 5.23 | 7.76 | 9.74 | 7.26 | 8.71 | 15.26 | 8.99 |

Means with the same letter in each column are not significantly different

mean comparison showed that fields A and J had significantly ($p<0.01$) the highest (50.30) and lowest (30.97%) severity, respectively.

*Faridan*

At first stage (early August), the minimum and maximum disease severity of 2.50 and 9.33%, respectively with significant difference ($p<0.05$) and average of 5.23% were observed (Table 3 and 4). At second stage (mid October) and also subsequent stages, the disease severity increased. The disease severity of 13.33 and 9.74 % were observed at second and third stages, respectively (Table 3 and 4). At sixth stage (late October), the average disease severity reached the peak (15.26%) which was two times more than fifth stage. Significant difference ($p<0.01$) was observed between the maximum (28.83%) and minimum (8.66%) disease severity. Fields D and H had the maximum (14.44%) and minimum (6.41%) disease severity ($p<0.01$).

*Semirom*

The highest disease severity was observed at third stage in both I and J fields (75.83%). The average disease severity in Semirom was 62.66%

**Table 5**. ANOVA results of powdery mildew disease severity in Semirom city

| S.O.V. | df | Sum of squares | Mean squares | F | Pr > F |
|---|---|---|---|---|---|
| Year | 1 | 15160.67 | 131.83 | 2.15 | 1.0001 |
| Replication (year) | 2 | 29.58 | 14.79 | 0.48 | 0.6176 |
| Fields | 9 | 2683.12 | 298.12 | 9.75 | 0.0001 |
| Stages | 5 | 10207.63 | 10207.63 | 166.39 | 0.0001 |
| Year × fields | 9 | 1962.18 | 59.4601 | 1.54 | 0.0029 |
| Year × stages | 5 | 32485.85 | 6497.17 | 212.55 | 0.0001 |
| Fields × stages | 45 | 148699.62 | 29739.92 | 484.77 | 0.0001 |
| Year×fields×stages | 45 | 24364.43 | 541.43 | 17.71 | 0.0001 |
| Error | 263 | 3606.91 | 30.56 | | |
| Total | 359 | 63169.91 | | | |

Mean = 43.136 RootMSE 5.33 C.V. = 12.82 $R^2$=0.94

**Table 6**. Mean disease severity for different fields in Semirom city

| | Disease severity at different stages | | | | | | |
|---|---|---|---|---|---|---|---|
| | First | Second | Third | Fourth | Fifth | Sixth | Total average |
| A | 58.33 c | 24.66 ab | 58.50 bc | 38.33 ac | 25.50 ab | 21.83 ab | 37.02 d |
| B | 55.00 c | 21.83 a | 67.83 ce | 40.33 ac | 44.66 e | 30.83 ab | 43.41 bc |
| C | 60.50 c | 19.66 a | 47.00 a | 40.83 ac | 16.33 a | 33.50 ab | 26.30 d |
| D | 70.00 d | 20.55 a | 53.33 ab | 45.33 bc | 31.83 cd | 16.31 ab | 40.02 c |
| E | 70.83 d | 33.66 c | 59.16 bd | 45.83 bc | 25.83 ac | 22.83 ab | 42.94 bc |
| F | 73.33 d | 30.66 bd | 59.16 bd | 45.83 bc | 25.83 ac | 22.83 ab | 42.94 bc |
| G | 73.33 d | 29.83 bc | 69.16 de | 34.66 ab | 28.16 bc | 21.50 ab | 42.77 bc |
| H | 73.33 d | 34.00 c | 60.83 bd | 50.33 cd | 40.33 de | 27.66 | 47.75 a |
| I | 19.66 a | 70.00 d | 75.83 e | 30.66 ac | 43.16 e | 23.66 ab | 43.83 bc |
| J | 34.00 b | 73.33 d | 75.83 e | 43.50 | 42.66 e | 21.33 a | 48.44 a |
| Mean | 58.83 | 35.81 | 62.66 | 42.93 | 32.24 | 26.31 | 38.71 |

Means with the same letter in each column are not significantly different

**Table 7**. ANOVA results of powdery mildew severity in Komeshcheh city

| S.O.V. | df | Sum of squares | Mean squares | F | Pr > F |
|---|---|---|---|---|---|
| Year | 1 | 5064.95 | 44.043 | 1.14 | 0.1696 |
| Replication (year) | 2 | 0.969 | 0.48 | 0.04 | 0.9600 |
| Fields | 9 | 9213.86 | 1023.76 | 86.18 | 0.0001 |
| Stages | 5 | 46.476 | 46.4762 | 1.20 | 0.2737 |
| Year × fields | 9 | 19538.384 | 592.0723 | 9.65 | 0.0001 |
| Year × stages | 5 | 1140.94 | 228.18 | 19.21 | 0.0001 |
| Fields × stages | 45 | 2973.50 | 594.700 | 15.35 | 0.0001 |
| Year × fields × stages | 45 | 3031.05 | 67.35 | 5.67 | 0.0001 |
| Error | 263 | 1401.69 | 11.87 | | |
| Total | 359 | 14788.52 | | | |

Mean = 9.861 RootMSE 3.45 C.V. = 18.15 $R^2$=0.91

with the fields J and C displaying the maximum (48.44%) and minimum (36.30%) mean ($p<0.01$), respectively. First stage ranked second with an average of 58.83%.

*Komeshcheh*

At first stage, the average disease severity, was 8.24% with the maximum and minimum of 22.16 (field D) and 2.50% (fields I and J), respectively. The disease severity increased at next stages so that at sixth stage, the highest severity of 30.16% was observed (Table 8). At sixth stage, the maximum and minimum of severity was recorded in fields D (21.22%) and I (3.13%), respectively ($p<0.01$).

*The disease severity in Isfahan province*

Tables 9 and 10 show the average disease severity results in Isfahan province. At the first stage, significant difference was observed among fields with maximum and minimum severity of 33.37 and 15.16%, respectively. The highest average severity (29.45%) was observed at the third stage with minimum and maximum of 25.16 and 36.04%, respectively. Mean comparison of the results showed that the maximum and minimum

**Table 8**. Mean disease severity for different fields in Komeshcheh city

| | Disease severity at different stages | | | | | | |
|---|---|---|---|---|---|---|---|
| | First | Second | Third | Fourth | Fifth | Sixth | Total average |
| A | 15.16 b | 21.66 d | 16.33 bc | 8.33 cd | 23.66 c | 28.50 b | 18.944 a |
| B | 11.83 b | 19.00 cd | 28.33 d | 9.16 d | 21.33 bc | 30.16 b | 19.942 a |
| C | 5.83 a | 12.16 b | 9.50 abcd | 6.83 ad | 15.83 bd | 26.66 b | 12.806 b |
| D | 22.16 c | 16.33 bc | 22.83 | 7.33 bd | 29.83 | 28.83 b | 21.222 a |
| E | 11.50 b | 5.33 a | 3.16 a | 4.50 ac | 2.33 a | 4.50 a | 5.222c |
| F | 2.50 a | 6.50 a | 4.50 a | 3.00 | 7.16 a | 4.00 a | 4.611 c |
| G | 4.50 a | 3.16 a | 1.83 a | 6.50 a | 6.50 a | 3.50 a | 4.333 c |
| H | 3.83 a | 5.50 a | 1.83 a | 4.00 ab | 7.66 a | 3.00 a | 4.306 a |
| I | 2.50 a | 3.50 a | 3.33 a | 3.16 a | 4.33 a | 2.00 a | 3.139 c |
| J | 2.66 a | 2.66 a | 2.66 a | 6.83 ad | 5.00 a | 4.50 a | 4.056 c |
| Mean | 8.24 | 9.58 | 9.43 | 5.96 | 12.36 | 13.56 | 9.861 |

Means with the same letter in each column are not significantly different

**Table 9**. ANOVA results of powdery mildew severity in Isfahan province

| S.O.V. | df | Sum of squares | Mean squares | F | Pr > F |
|---|---|---|---|---|---|
| Year | 1 | 1.253 | 1.253 | 2.82 | 0.0933 |
| Replication (year) | 2 | 84.18 | 10.52 | 0.08 | 0.9997 |
| Fields | 9 | 185325.31 | 61441.77 | 5838.47 | 0.0001 |
| Stages | 5 | 7677.96 | 853.10 | 6.43 | 0.0001 |
| Year × fields | 9 | 4.040 | 1.010 | 0.373 | 0.8250 |
| Year x stages | 5 | 25.768 | 5.1536 | 11.61 | 0.0001 |
| Fields× stages | 45 | 14589.55 | 540.35 | 4.07 | 0.0001 |
| Year×fields×stages | 45 | 57.78 | 0.5024 | 1.13 | 0.1781 |
| Error | 263 | 89219.47 | 132.76 | | |
| Total | 359 | 295896.49 | | | |

Mean = 25.376 RootMSE 11.52 C.V. = 25.00 R2=0.70

**Table 10**. Mean disease severity in Isfahan province

| | Disease severity at different stages | | | | | | |
|---|---|---|---|---|---|---|---|
| | First | Second | Third | Fourth | Fifth | Sixth | Total average |
| A | 33.37 a | 23.04 a | 32.16 a | 32.20 a | 30.50 ab | 24.95 abc | 29.37 ab |
| B | 30.70 a | 22.16 a | 36.04 a | 30.50 a | 37.00 b | 27.83 bc | 30.70 a |
| C | 24.33 a | 20.62 a | 29.08 a | 31.04 a | 28.25 ab | 29.37 c | 27.11 ad |
| D | 31.79 a | 23.29 a | 31.66 a | 26.20 a | 32.33 ab | 29.33 c | 29.10 ac |
| E | 31.29 a | 21.41 a | 28.58 a | 28.58 a | 20.54 ab | 19.83 ab | 25.04 ae |
| F | 30.75 a | 22.12 a | 28.62 a | 26.33 a | 17.70 a | 17.41 a | 23.82 ae |
| G | 29.87 a | 18.83 a | 25.16 a | 21.87 a | 21.33 ab | 16.83 a | 22.31 ae |
| H | 28.75 a | 18.62 a | 25.37 a | 22.50 a | 21.04 ab | 18.00 a | 22.38 ae |
| I | 15.16 a | 28.50 a | 29.08 a | 16.41 a | 21.75 ab | 16.70 a | 21.27 ae |
| J | 18.70 a | 28.25 a | 28.83 a | 21.16 a | 22.83 ab | 15.91 a | 22.61 ae |
| Mean | 27.47 | 22.66 | 29.45 | 25.67 | 25.32 | 21.16 | 25.37 |

Means with the same letter in each column are not significantly different

mean severity was observed in fields B (30.70%) and I (21.27%), respectively.

## DISCUSSION

Results showed the presence and distribution of powdery mildew in sugar beet fields with considerable intensity. In Isfahan city, the disease occurrence was reported from early August to late November with an average of 39.50% severity. The peak of the severity was found late September to late October so that in late September, the severity percentage (46.56) was 9 and 10.6 times higher than the first and third stages, respectively. Shaykholeslami et al. (2005) reported that the disease severity progressed from late July to late November and reached the peak late September. The severity reduction at sixth stage was owing to the average heat temperature of 13.5 $^{o}$C (5-21.9 $^{o}$C), rainfall occurrence and terminal physiological growth of the plants. These results are similar to those reported by Ahmadinejad (1973), Jafari (1970), and Asher (1979, 1990, 2002).

Results in Faridan city showed the severity and importance of the disease with a total average of > 9%. The lower disease severity was due to the

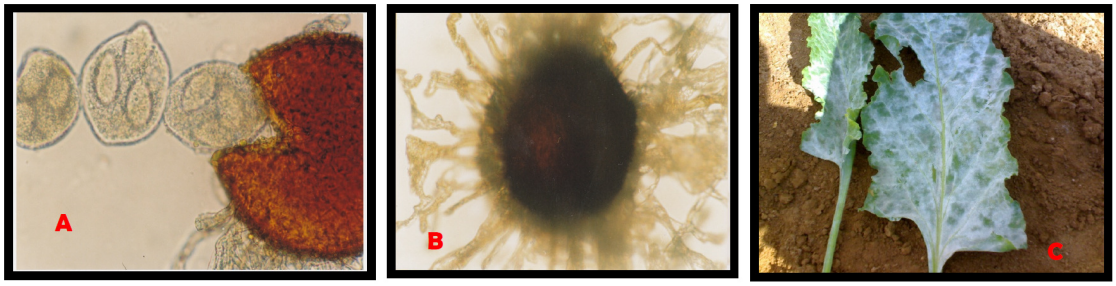


**Figure 1**. A. Powdery mildew symptoms on sugar beet leaf, B. matured cleistothecium, C. Movement of asci sacs including ascospores into the outside of cleistothecium

usage of sprinkler irrigation. Because of cold weather condition in Faridan, sampling was carried out from mid September to late October. The disease severity reduction at the first and second stages was due to the rainfall occurrence and increase in the severity at the following stages (especially late September) was due to 12-28 $^{o}$C (average of 20 $^{o}$C) temperature and 38% humidity conditions. The lack of rainfall and irrigation at the end of the growing season (fifth and sixth stages) resulted in increase of disease severity (Shaykholeslami et al. 2004, 2005).

High powdery mildew disease severity (> 43%) was observed in Semirom city. The average daily temperature was 23.1 $^{o}$C (17.5-28.7 $^{o}$C) with 28% humidity. At sixth stage, the disease severity decreased to 26.31% which was 32.52 and 36.35% lower than the first and third stages.

In Komeshcheh region, the total average of disease severity was found to be 10%. Using sprinkler irrigation, mycelium and spores were removed from the leaf surface and as a result, disease severity was reduced. In this region, because of irrigation cessation before harvest, the disease severity increased from fourth stage onwards. Therefore, the role of sprinkler irrigation in disease severity reduction is considerable (Mohammadi Gooltape et al. 1999).

*Average sugar beet infection in Isfahan province*

The average disease severity in Isfahan province was 25.37% which is considerable. In Iran, sugar beet yield reduction is higher than the other countries which might be due to the presence of pest and different diseases such as powdery mildew (Jafari 1970; Behdad 2006). Results showed that the disease severity was 27.47% in early August but at the second stage, the severity decreased because of rainfall occurrence. The disease progress in late September was due to the lack of rainfall, relative humidity and optimal temperature. Ahmadinejad (1973) showed that *E. betae* is not active at high temperature. Therefore, in mid September, the fungus progress was low and in late September when the humidity increased and the temperature decreased, the fungus activity began. From mid-September, brown spots (cleistothecia) were appeared. Cleistothecium is the main factor for fungus overwintering and the disease transmission from one year to another. Since this fungus has secondary host so the fungus can overwinter in weeds or sugar beet plant debris. From early October, because of temperature reduction, scattered rainfall, and terminal physiological growth of the plants, the severity decreased. Fourth to sixth samplings confirmed these results. Such results are in accord with the findings of Shaykholeslami et al. (2004, 2005) and Basati (2003, 2005). Studies on the sexual and asexual forms of the fungus (Figure 1), confirmed Jafary (1970), Ahmadinejad (1973), and Shaykholeslami et al. (2004, 2005) results on cleistothecia, asci, and ascopores. This study showed that the powdery mildew is caused by *E. betae* fungus and that the cleistothecium is the main factor of the disease progress in the following years. Reproduction, development, and spread of the disease during the growing season were performed by the asexual form corresponding with Lewellen and Schrandt (2001) study.

In general, it was shown that powdery mildew is one of the most important diseases in sugar beet production areas. The fungus was also found in weeds and the sexual form of it was observed at the end of the growing season. Therefore, it seems that the fungus can overwinter in weeds and plant debris in sexual form from year to year and then becomes activate and infects sugar beet fields (Rapple et al. 1975; Drandarewski 1978). Therefore, it is necessary that management practices including breeding, biological, appropriate fungicide application in early disease development in the field and, in total, integrated methods be performed to prevent the qualitative and quanti-

tative decrease in sugar beet crop (Basati 2003, 2004).

## REFERENCES


Ahmadinejad A. Studies on powdery mildew of sugar beet. Iranian Journal of Plant Pathology. 1971; 9(2): 20-25. (in Persian, abstract in English)

Anonymous. Diseases Assessment Manuel for Crop Variety Triales. Natio. Ins. Agric. Bot. Cambridge. 1985; CB3OLE.

Asher M, Williams G. Controlling leaf disease: powdery mildew. British Sugar Beet Review. 1992; 60: 35-37.

Asher M. Forecasting powdery mildew. British Sugar Beet Review. 1990; 58: 35-37.

Asher M. Disease in 2001 and their control. British Sugar Beet Review. 2002; 70: 30-33.

Asher M. Investigation on the infection yield loss relations for sugar beet powdery mildew, *Erysiphy betae* (vanha) wetzien, under differing susceptibility. Universidad Bonn. 1979; Germany, 109 p.

Basati J, Mesbah M, Karimzadeh G, Sadeghiyan SY. Genetical analysis of resistance to powdery mildew on sugar beet. 2005; Journal of Sugar beet, 21(2): 105-122. (in Persian, abstract in English)

Behdad E. Phytopathology and Import ant Diseases of Iran. Atre Etrad Publications. 2006; pp 785. (in Persian)

Cock DA and Scott, RK. The sugar beet crop. First edition: Chapman and Hall. 1993; pp 675.

Cousens R. Misinterpretation of results in weed research through inappropriate use of statistics. Weed Res. 1988; 28: 281-284.

Ershad D. Fungi of Iran. Ministry of Jihad-e- Agriculture, Agricultural Research, Education and Extention Organization. 2009; pp 535.

Anonymous. FAOSTAT Database results from FAO website. 2010; http://apps.fao.org/servlet/Xte Servlet.

Jafary A. Powdery mildew of Iran. Iranian Journal of plant Pathology. 1970; 6 (3 and 4). (in Persian)

Lewellen RT, Schrandt JK. Inheritance of powdery mildew resistance in sugar beet derived from *Beta vulgaris* subsp.*maritima* .Plant Disease. 2001; D- 2001 – 0413-01R (on-line).

Mohammadi Gooltape E, Pakdaman B, and Rezaee Danesh. Pests and Diseases of Sugar Beet, Tarbiyat Modares University.1999; pp 278. (in Persian)

Nasr Esfahani M. Principle of Diagnostic Techniques in Plant Pathology. Gholami Publication, Theran. 2010; PP 294. (in Persian)

Ruppel EG, Hill FJ, Mumford, E. Epidemiological observation on the sugar beet powdery mildew, epiphytotic in western U.S.A.. Plant Disease Reporter. 1975; 59: 283-285.

SAS Institute. SAS/STAT User's Guide. Version 9.1.3. 2004; Cary: SAS Institute Inc.

Schweizer, EE, May MJ. Weeds and weed control. The sugar beet crop. First edition Chapman and Hall. Chapter. 1993; 12: 485-519.

Schweizer EE. Common lambsquarters (*Chenopodium album*) interference in sugar beets (*Beta vulgaris*). Weed Sci. 1983; 31: 5-8.

Shaykholeslami M, Okhovate SM, Hajarod G, Sharifi Tehrani E, Javankhah M. Genetical diversity of *Erysiphye betae*. Study on genetic diversity of Iranian populations of *Erysiphe betae* (Vanha) Weltzien causal agent of sugar beet powdery mildew using rDNA-RFLP method. Journal of Sugar Beet. 2004; 20(2): 149-159. (in Persian, abstract in English)

Shaykholeslami M, Okhovate SM, Hajarod G, Sharifi Tehrani E, Javankhah M. Studies on Sustainability of *Erysiphye betae*. Powdery mildew of sugar beet in Karaj and Ghazvin regions, Iranian Journal of Agri Science. 2005; 36(6):1381-1389. (in Persian, abstract in English).