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# Yield Loss Due to Leaf Rust on Barley at Different Sowing Dates

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**Abstract:** Yield loss studies on barley leaf rust (BLR), caused by *Puccinia hordei* Otth, were conducted for 3 years between 2003 and 2005 at Ambo Plant Protection Research Centre of the Institute of Agricultural Research. A susceptible variety 'Trompillo' was used. The experiments were conducted in a split plot design with 4 sowing dates assigned to main plots and fungicide unsprayed and sprayed treatments to subplots. Means of disease severity for unsprayed treatments ranged from AUDPC 661-1278, while that of the sprayed treatments were 0.0. Late planting had a negative effect on grain yield (GY) and thousand kernel weight (TKW). Moreover, the fungicide unsprayed treatments were significantly lower in GY, TKW and kernels per spike (KPS) as compared to the sprayed treatments. Interaction effects between sowing date and fungicide treatments were also significant. Differences between unsprayed and sprayed treatments increased in all selected yield parameters as the sowing date was delayed. The losses in GY due to BLR for the 4 sowing dates ranged from 6.9-40.2%; for TKW from 5.9-27.6% and for KPS from 0-16.5%. Under normal sowing date (June 16), the losses for GY, TKW and KPS were 23.4, 14.3 and 0.2%, respectively. There were highly significant negative correlations between BLR severity and GY and between BLR and TKW. These results confirm the economic importance of BLR on barley.

**Key words:** Barley leaf rust, *Puccinia hordei*, sowing date, yield, kernel and loss

## INTRODUCTION

Barley leaf rust, caused by *Puccinia hordei* Otth is a common fungal disease in the highlands of Ethiopia (Dagnachew, 1967). The disease was first reported in Ethiopia by Stewart and Dagnechew (1967) and has become widespread in all barley growing regions of Ethiopia causing heavy losses (Fekadu, 1995). Surveys conducted in the past indicated a severity range of 80-100% in many fields of Arsi, Bale, Wellega, Gojam and Parts of Shewa regions (SPL, 1986). Epidemics of leaf rust have been recovered in the Ambo, the Adet, the Sinana, the Shashemene and the Jima areas (Yitbarek *et al*., 1996; Getaneh and Temesgen, 1996).

The disease is characterized by small, round, yellow-brown pustules occurring mainly on the leaves or leaf sheaths. Later in the season round to oblong, dark brown, telial pustules develop (Stubbs *et al*., 1986). The uredia often serve as sources of primary inoculum of this pathogen. Long distance dispersal of the urediospores is by way of wind (Stubbs *et al*., 1986).

Barley leaf rust is known to cause serious yield losses in the countries of North Africa and in Pakistan (Stubbs *et al*., 1986). A yield loss of 23% was registered in Canada (Melville *et al*., 1976). In Holland, heavily and lightly rusted barley were sprayed with a fungicide at heading time and yield increases of 30 and 10%, respectively, were obtained showed yield increases of 17-31% (Melville *et al*., 1976). Moreover, losses can be great particularly when the pathogen infects plants early and also infects the flag leaf (King and Polley, 1976). It causes shriveled kernels, a decrease in kernel number, adverse effect on malting quality (Stubbs *et al*., 1986; Mathre, 1987) and reduces vigour and plant growth by increasing transpiration, respiration and reducing photosynthesis (Sapkal *et al*., 1992). Yield losses due to barley leaf rust vary with sowing date (Peresipkin, 1979; Melville *et al*., 1976). However, there is a lack of information on the development of foliar diseases and their effects on the yield of barley planted at different sowing dates in Ethiopia. Attempts made to study yield losses due to the disease failed because of interference

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of other diseases (Eshetu, 1985). The purposes of this study were to determine the economic importance of barley leaf rust and its effect on yields of barley planted at different sowing dates.

## MATERIALS AND METHODS

The barley variety 'Trompillo' which is susceptible to barley leaf rust, but resistant to other major leaf diseases, was hand sown at the Ambo Plant Protection Research Centre of the Institute of Agricultural Research during the 2003, 2004 and 2005 cropping seasons. The effects of sowing dates and fungicides application were compared using a split plot design with 4 replications. Four sowing dates (June 1 and 16, July 1 and 16) were assigned to main plots and fungicide treatments (sprayed and unsprayed) to sub-plots. Plots were 6 rows of 2.5 m length and 1.2 m width. The net plot was 4 central rows of 2.0 by 0.8 m to reduce spray drifts, buffer zones were created by planting 3 rows of oats between plots and replications. The fungicides propiconazole (tilt) was applied on the chemically treated plots every 10 days at the rate of 0.5 $ha^{-1}$. The trials were carried out under natural barley leaf rust infection.

Barley leaf rust severity was estimated by taking the percent leaf area affected at 10 days interval, starting from the first appearance of the symptom. Such ratings were taken 5 times during the growing period. The area under disease progress curve (AUDPC) was computed from the percentage leaf area affected. The growth stage of the plants was recorded by using Zadok's scale as modified by Stubbs *et al*. (1986). Yield loss was calculated as the difference between mean yield of fungicide sprayed and unsprayed plots (FAO, 1971). Thousand kernel weight and kernel number per spike losses were computed similarly. Barley leaf rust severity, grain yield per hectare, thousand kernel weight and kernel number per spike of unsprayed and sprayed plots within the same and across sowing date (s) were compared by using analysis of variance and least significant difference tests. Correlation analyses were calculated for barley leaf rust severity and selected yield parameters.

## RESULTS

The overall mean severity of Barley leaf rust as expressed by AUDPC, for the 3 years, during 2003-2005 cropping seasons, ranged from 661-1277.7. The severity of the disease increased significantly between the first (June 1) and the last 3 (June 16, July 1 and 16) sowing dates. There were no significant differences in the disease severity among the last 3 sowing dates. However, infection started earlier on the second (June 16) than on the 1st, on the 3rd than on the 2nd and on the 4th than on the 3rd sowing dates, which enabled the disease to have more time to cause more damage to the crop (Table 1).

Yield of barley crop was negatively affected by late sowing date. Grain yield decreased significantly as the sowing date was delayed. The highest mean yields were obtained from earlier sowing dates. The mean grain yields of the fungicide unsprayed treatments were significantly lower due to the disease as compared to the sprayed treatments. The differences between the 2 treatments increased as the date of sowing was delayed. There were also highly significant differences in the sowing date by fungicide treatment interactions. Hence, grain yield losses due to barley leaf rust ranged from 6.9% for the first to 40.2% for the last sowing dates. The loss under normal sowing date (June 16) was 23.4% (Table 1). Table 2 indicates that the differences in thousand kernel weight were highly significant among the sowing dates between the fungicide unsprayed treatments and with their interactions. The difference in thousand kernel weight was probably because the weather condition had a negative effect on the plumpness of barley kernels when planted late. The highest thousand kernel weight was recorded for the first and the least for the 4th sowing date. But, the difference between the unsprayed and sprayed treatments was the effect of barley leaf rust on the crop and it increased as the sowing date was delayed. The losses ranged from 5.9% for the first to 27.6% for the 4th sowing date. The loss for the normal sowing date was 14.3%.

The effect of barley leaf rust on kernel number per spike is shown in Table 3. Means of kernel number per spike were statistically the same among the sowing dates, indicating that kernel number was not affected by planting date. Barley leaf rust severity has increased gradually, but the variation was significant between the first 2 and the last 2 sowing dates. This difference has been reflected in the increased losses in the number of kernels per spike between unsprayed and sprayed treatments in the last 2 sowing dates. The interaction of the sowing date by fungicide treatment was also significant. Losses ranged from 0% for the first to 16.5% for the last sowing dates. The loss for the normal sowing date was 0.25.

Barley leaf rust severity had negative significant effects on grain yield ($r = 0.574$, $p>0.01$) and on thousand kernel weight ($r = -0.743$, $p<0.01$). There was also a negative correlation between the disease and kernels per spike, but these relations were not significant ($r = -0.256$, $p = 0.05$).

Table 1: Effects of *Puccinia hordei* on grain yield of the susceptible barley variety 'Trompillo' planted at 4 sowing dates at Ambo, 2003-2005 crop seasons

| | | AUDPC** | | Yield (kg ha$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|
| Sowing date | *Growth stage | S | US | S | US | SD | Loss (%) |
| June 1*** | 5 | 0.0 | 661.0 | 4444.0 | 4138.0 | 4291.1 | 6.9 |
| June 16 | 4 | 0.0 | 1277.7 | 4458.0 | 3414.1 | 3936.0 | 23.4 |
| July 1 | 3 | 0.0 | 1173.7 | 4350.9 | 3104.9 | 3727.9 | 28.6 |
| July 16 | 2 | 0.0 | 1040.7 | 3449.0 | 2063.1 | 2756.2 | 40.2 |
| Mean | | 0.0 | 1038.3 | 4175.5 | 3180.1 | - | |

CV (%) 7.4; LSD (0.01); Sowing date (SD) 932.5; Fungicide (FG) NS; SD × FG 586.5; * Growth stage: 5 = heading; 4 = booting; 3 = stem elongation and 2 = tillering; ** S = Sprayed and US = Unsprayed; *** Means for 2003 and 2005 crop seasons only

Table 2: Effects of *Puccinia hordei* on thousand kernel weight (TWK) of the susceptible barley variety 'Trompillo' planted at 4 sowing dates at Ambo, 2003-2005 crop seasons

| | AUDPC | | TKW (g) | | | |
|---|---|---|---|---|---|---|
| Sowing date | S | US | S | US | SD | Loss (%) |
| June 1* | 0.0 | 661.0 | 33.8 | 31.8 | 32.8 | 5.9 |
| June 16 | 0.0 | 1277.7 | 31.4 | 26.9 | 29.2 | 14.3 |
| July 1 | 0.0 | 1173.7 | 29.9 | 22.7 | 26.3 | 24.1 |
| July 16 | 0.0 | 1040.7 | 28.6 | 20.7 | 24.7 | 27.6 |
| Mean | 0.0 | 1038.3 | 30.9 | 25.3 | - | |

CV (%) 41; LSD (0.01); Sowing date (SD) 2.7; Fungicide (FG) NS; SD × FG 2.5

Table 3: Effects of *Puccinia hordei* on the number of kernels per spike of the susceptible barley variety 'Trompillo' planted at 4 sowing dates at Ambo, 2003-2005 crop seasons

| | | AUDPC** | | Yield (kg ha$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|
| Sowing date | *Growth stage | S | US | S | US | SD | Loss (%) |
| June 1 | 5 | 0.0 | 707.0 | 42.7 | 42.7 | 42.7 | 0.00 |
| June 16 | 4 | 0.0 | 918.0 | 39.7 | 39.6 | 39.6 | 0.20 |
| July 1 | 3 | 0.0 | 1016.0 | 43.0 | 40.7 | 41.8 | 5.30 |
| July 16 | 2 | 0.0 | 1107.0 | 51.5 | 43.0 | 47.2 | 16.50 |
| Mean | - | 0.00 | 937.0 | 44.2 | 41.5 | - | |

CV (%) 5.8; LSD (0.01); Sowing date (SD) NS; Fungicide (FG) NS; SD × FG 3.8

## DISCUSSION

Barley leaf rust appeared on the 1st sowing date at growth stage 5, while on the 2nd sowing it was at growth stage 4, or about 9 days earlier than on the first. On the 3rd sowing date, the rust appeared at growth stage 3, or 16 days earlier than on the 1st and on the 4th, it was seen at growth stage 3, or 21 days earlier than on the first sowing date. The mean barley leaf rust severity increased significantly between the 1st and the rest of the sowing date. The mean barley leaf rust severity increased significantly between the first and the rest of the sowing dates. The losses in grain yield and thousand kernel weight were also different accordingly. In the later 3 sowing dates, however, the disease severity was similar.

In contrast, the grain yield, thousand kernel weight and kernel number per spike losses increased as the sowing date was delayed. As indicated above, the infection period for each sowing date increased as the sowing date progressed further.

The exposure of barley crop for the disease was longest on the 4th and least on the second sowing dates. This would mean that the earlier the infection, the more losses the disease caused. Consequently, even though the later 3 sowing dates had similar disease severity, the losses in grain yields increased from 23.4-40.2%, for thousand kernel weight from 14.3-27.6% and for kernel number from 0.2-16.5%. This result is in agreement with that of Mathre (1987) which indicated that losses could be great particularly when the pathogen infects the crop at early growth stage or the time of arrival of the inoculum in relation to the stage of the crop development is one of the major factors that determines the amount of losses (Rasmusson *et al.*, 1985). In addition, the losses could also be increased because the unsprayed treatments reached maturing much earlier (10 days) than the sprayed ones and there could also be a loss of characteristically small grains in unsprayed plots during threshing.

The similarity of barley leaf rust severity among the later 3 sowing dates may be partly due to limitations in the accuracy of disease assessment. In particular, assessment was confined to the leaf lamina whereas field observations indicated that in the unsprayed plots infection of the leaf sheath was common especially during 2003 crop season and could have continued to affect yield after death of the leaf lamina.

In the first sowing date, when barley was affected at the heading stage, the loss was due to the reduction in kernel size. But, when the crop was infected earlier than heading stage loss in kernel number per spike was observed. This loss increased and reached the maximum on the 4th planting date (Table 3). These findings agree with those of Melville (1976) which stated that barley leaf rust infection after heading decreased grain weight and infection before heading was likely to affect either tiller number or number of grains per spike.

Grain yields and thousand kernel weights of the 4 sowing dates were significantly different. The maximum yield and kernel weight obtained were on the first sowing date and declined as the sowing dates progressed late in the season. This could be the adverse effect of the weather condition that prevailed at the end of the rainy season for the late sown barley. In September and October, the rain was less than in earlier months. Similar results were also recorded in Holetta Research Centre in 1971/1972 season (IAR, 1972) but the reason for this was not explained.

The highly significant correlation between the thousand kernel weight and the severity of leaf rust suggests that the disease influences the yield of barley mainly through its effect on the kernel weight.

## CONCLUSION

This study has confirmed the economic importance of barley leaf rust, caused by *Puccinia hordei*, on barley and it is suggested that the barley improvement programme should include activities to tackle this disease.

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