Discovery
Agriculture

7(18), 2021

Estimation of yield loss on wheat genotypes due to foliar blight disease in Nepal

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To Cite:
Baidya S, Thapa DB, Bhandari D. Estimation of yield loss on wheat genotypes due to foliar blight disease in Nepal. *Discovery Agriculture*, 2021, 7(18), 158-165

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Peer-Review History
Received: 22 June 2021
Reviewed & Revised: 24/June/2021 to 23/July/2021
Accepted: 26 July 2021
Published: August 2021

Peer-Review Model
External peer-review was done through double-blind method.

ABSTRACT

Foliar blight (FB) caused by *Bipolaris sorokiniana* and *Pyrenophora tritici repentis* either individual or in combination of both pathogens is regarded as an important wheat disease in Nepal due to its high disease frequency in plain and mid hill of the country. Yield loss assessment field experiments were conducted on six genotypes *viz*. Tilottama, Aditya, Bhrikuti, Gautam, Vijaya and RR21 at National Plant Pathology Research Centre (NPPRC), Khumaltar represent for mid hill and National Maize Research Council (NMRP), Chitwan represent for plain area in a split plot randomized complete block design (RCBD) in three replications. Fungicide Propiconazole (Tilt 250 EC) was applied as a foliar spray to the wheat genotypes as the sub plot treatment to estimate yield loss due to the disease infection. A double digit scale was used to measure foliar infection, and severity was calculated area under the disease progress curve (AUDPC). Finally, grain yield was recorded and analysed by using Microsoft excel and MSTAT. The percentage of yield loss was varying with genotypes and fungicide application. Higher amount of yield loss was recorded on genotype RR 21(27.36%) and lower amount of yield loss calculated genotype Gautam (13.19%) followed by genotypes Aditya (16.44%) and Tilottama (17.96%) respectively. With low value to AUDPC and high value to grain yield were recorded in genotype Bhrikuti as compared to other genotypes. Response of variety X fungicide was not significant difference in term of total grain yield however the value of AUDPC was difference.

Keywords: AUDPC, Foliar blight, *Bipolaris sorokiniana, Pyrenophora tritici repentis*, Yield loss

1. INTRODUCTION

Wheat is the major cereal crop of Nepal after rice and maize. Wheat was grown in 0.704 millions ha obtaining a total production of 2.01 million metric tons of grains with a productivity of 2.85 t ha^{-1} in 2019/20 (MoALD 2020). There are common constraints like biotic, abiotic, high cost of production, low farm gate price etc that affect on the production of wheat in Nepal. Foliar leaf blight is a serious disease of wheat in Nepal after rust disease caused individually or in combination by *Bipolaris sorokiniana* and *Pyrenophora tritici-repentis*. The pathogen *B. sorokiniana* and *P. tritici repentis* were isolated by 80% and 20% respectively from leaf samples collected from Kathmandu valley (PPD 2013).

Based on symptom observations in the field, it is often impossible to determine if a lesion is caused by one pathogen or the other. In recent years, the magnitude and severity of foliar blight have extended from the Terai/plain region (100 masl) to the hilly region (2400 masl). It is considered a disease of major importance because of its potential to cause yield loss. Prior to 1990, the pathogen *P. tritici-repentis* was considered important in causing leaf blight, but later *B. sorokiniana* was found to be predominant and responsible to cause the disease. The main inoculum sources are free dormant conidia in the soil, infected seeds, crop reduces and other host plants. The persisted inoculums cause pre and post emergence damping off, root rot, sub crown internode infection and seedling blight during early stages (Saari 1986, Mehta 1993). This change in pathogen dominance may be due to environmental change and the introduction of new genotyepes (Shrestha et al 1998). Spot blotch is common and occurs every year in the warm wheat growing area of the country with an average yield loss of 15%, but it may reach up to 34% under farmers' field condition (Sharma et al 2003).

The magnitudes of yield loss due to the foliar blight vary with location and years. Based on the survey report it was estimated 40-50% and up to 90% yield loss on wheat genotype RR21 in hill and plain areas respectively (Karki and Sharma 1990). Similarly, grain yield loss was difference with genotypes that Ning 8319, Nepal 297 and RR21 had 3%, 15% and 24% respectively (Mahto 1995). Likewise, grain yield loss trial showed losses as high as 25% and 16% in wheat genotypes Sonalika and UP 262 in on-station and farmers' field conditions (Mahto 1996; Dubin and Bimb 1991). The yield loss due to spot blotch disease has been reported about 16% in farmers' field whereas 26% yield loss had reported in on-farm trial at Bhairahawa (Bhatt et al 1998). Hence, this study focus to estimate actual yield loss on commonly cultivated wheat genotypes in plain and mid hill of the country.

2. MATERIALS AND METHODS

The field experiments were conducted at National Plant Pathology Research Centre (NPPRC), Khumaltar represents for mid hill and National Maize Research Council (NMRP), Chitwan represent for plain area in a split plot randomized complete block design (RCBD) in three replications. The size of each plot was 4.5 m^2. Six commonly planted genotypes Bhrikuti, Tilottama, Aditya, Bijaya, Gautam and RR21 were evaluated in protected and non-protected field conditions. The plots were protected with applying systemic fungicide Propiconazole (Tilt). The fungicide was applied @ 0.75 ml per litre of water as a foliar spray to the crop as the sub plot treatment to estimate yield losses due to foliar blight infection. Chemical fertilizers were applied at the rate of 100:30:30 $N:P_2O_5:K_2O$ kg ha^{-1}. All P_2O_5 and K_2O and half dose of nitrogen were applied with compost @ 10 t ha^{-1} during the final land preparation. The remaining half N was top dressed into two split at tillering and panicle initiation stage of the crop. Three times hand weeding and two times irrigation in one month interval were also applied during cropping time.

A double digit scale was used to measure foliar infection, where the first digit equated to the height of infection and the second digit to the infection severity. Scale gradations were 1-9. For height of infection, a score of 5 was for plants with infection up to the plant center, and for a score of 9 the infection had spread to the flag leaf. A disease severity score of 1 was for infected leaves exhibiting low disease symptoms, whereas a score of 9 reflected total leaf destruction. Grain infection at maturity scored on a 1-5 scale, with 1 being low and 5 representing a high seed blemish at embryo points. The growth stages of wheat recorded using the scale developed by Zadoks et al 1974. Finally, grain yield was recorded and data was analyzed by using Microsoft excel and MSTAT. Descriptive analysis was also performed.

Foliar blight severity was measured as percent lesions on the flag (F) and F-1 leaves on individual plants in each plot. Readings were averaged for F and F-1. Three readings were taken and used to calculate area under the disease progress curve (AUDPC).

$$AUDPC = \sum_{i=1}^{n} [(Y_{i+1} + Y_i) \times 0.5] [T_{i+1} - T_i]$$

Where Yi =Foliar blight severity (%) at i^{th} observation, T_i = time (days) of the i^{th} observation, and n = total number of observation
The experiment was subjected to natural infection of both pathogen *B. sorokiniana* and *P. tritici-repentis*. Combined ANOVA was performed and appropriate LSD (P=0.05) calculated for key variables.

3. RESULT

The percentage of yield loss was varying with genotypes and fungicide application. In Chitwan, higher yield loss was estimated in genotype RR 21(27.36%) and lower percentage of yield loss recorded in genotype Gautam (13.19%) followed by genotypes Aditya (16.44%) and Tilottama (17.96%) respectively. Similarly, in Khumaltar, higher yield loss was estimated in genotype Gautam

(27.31%) followed by Tilottama (25%) and Aditya (23.25%) respectively. The level of AUDPC of FB was significantly low in sprayed plot with respect to the genotypes (Figure 1). With low value to AUDPC and high value to grain yield were recorded in genotype Bhrikuti as compared to other genotypes. Most of the genotypes recorded high value of AUDPC of Foliar blight disease in Plain/ Terai area as compared to mid hill area except genotypes Aditya and Vijaya (Figure 2). Low value of AUDPC was observed in Bhrikuti in both locations. Similarly, infection rate was also significantly difference in flag leaves in term of genotypes and fungicide application (Figure 3). Response of variety X fungicide was not significant difference in term of total grain yield however the value of AUDPC was difference (Table 1).

Low yield loss was estimated in genotype Bhrikuti followed by vijaya in Khumaltar condition (Figure 3) whereas low yield loss recorded in genotype Gautam followed by genotypes Vijaya and Bhrikuti (Figure 4). Similarly, when total grain yield loss was estimated from both locations as combined analysis, higher grain yield loss was recorded in genotype RR21 where low yield loss were recorded in Bhrikuti and Aditya (Figure 5 and Table 1).

Table 1. Impact of fungicide application (Sprayed vs. Non-sprayed) on yield loss in six different wheat genotypes at Khumaltar and Chitwan conditions

Genotypes	**AUDPC**		**FB- Flag Leaf (%)**		**Khumaltar** Yield (Kg /4.5m²)			**Chitwan** Yield (Kg /4.5m²)			**Combined locations** Yield (Kg /4.5m²)			**Yield (T/ha) Sprayed**
	Spray	**Non- Spray**	**Spray**	**Non- Spray**	**Sprayed (Kg)**	**Non-sprayed (Kg)**	**Yield loss (%)**	**Sprayed (Kg)**	**Non-sprayed (Kg)**	**Yield loss (%)**	**Sprayed (Kg)**	**Non-sprayed (Kg)**	**Yield loss (%)**	
Tilottama	163	511	21	56	2.80	2.10	25	2.45	2.01	17.96	2.63	2.06	21.71	5.83
Aditya	138	319	15	29	2.71	2.08	23.25	2.39	1.92	19.67	2.55	2.0	21.57	5.66
Vijaya	165	361	19	38	2.43	1.92	20.99	2.19	1.83	16.44	2.31	1.88	18.83	5.13
Bhrikuti	94	274	8	27	2.64	2.15	18.56	2.40	1.96	18.33	2.52	2.06	18.45	5.60
Gautam	122	385	14	41	2.71	1.97	27.31	2.35	2.04	13.19	2.53	2.0	20.75	5.62
RR 21	310	855	38	61	2.20	1.73	21.36	1.96	1.42	27.36	2.08	1.58	24.28	4.62
Mean	165	450			2.58	1.99		2.29	1.86		2.43	1.93		5.41
F-test														
Fungicide (A)	**	**			*	*		**	**		**	**		*
Variety (B)	**	**			**	**		**	**		**	**		*
A * B	**	*			NS	NS		NS	NS		NS	NS		NS
LSD (0.05)	28	51			0.29	0.21		0.22	0.16		0.21	0.13		0.68
CV %	8.74	9.59			8.16	7.95		8.12	9.83		7.52	5.94		12.6

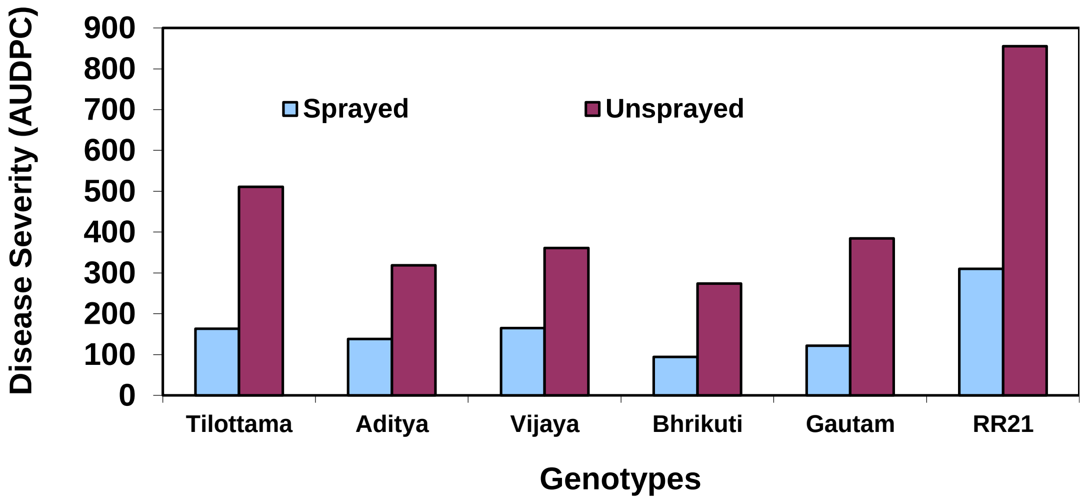

Figure 1. Foliar blight severity (AUDPC) of wheat varieties under fungicide protection

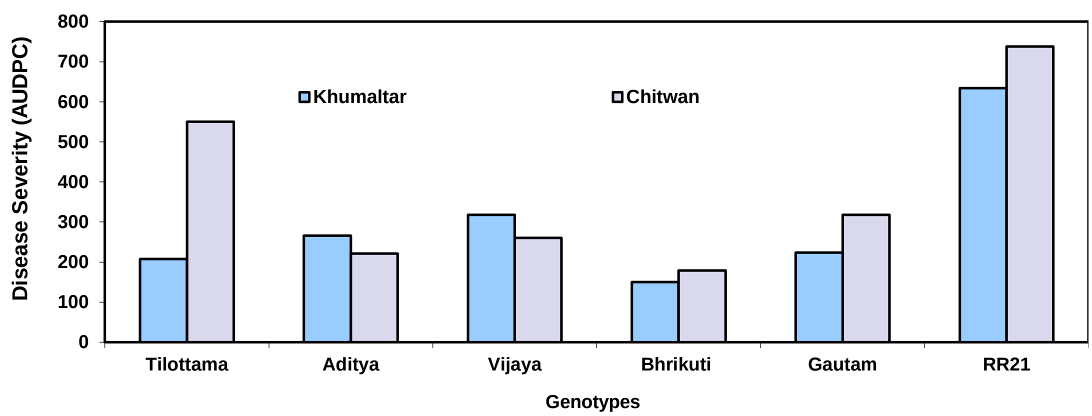

Figure 2. Foliar blight severity (AUDPC) of wheat genotypes at Khumaltar and Chitwan conditions

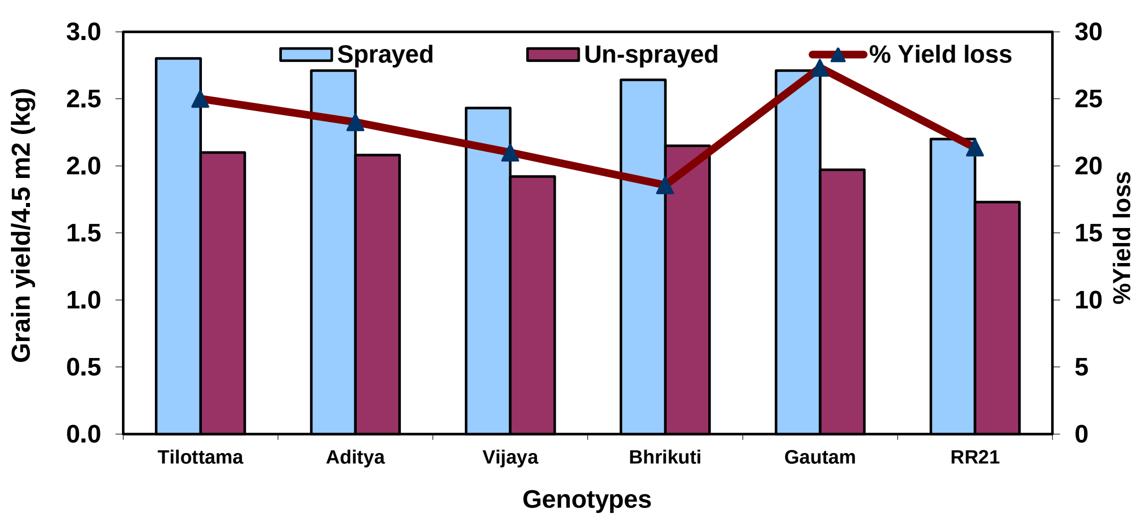

Figure 3. Yield performance in different genotypes at Khumaltar in treated and non-treated condition

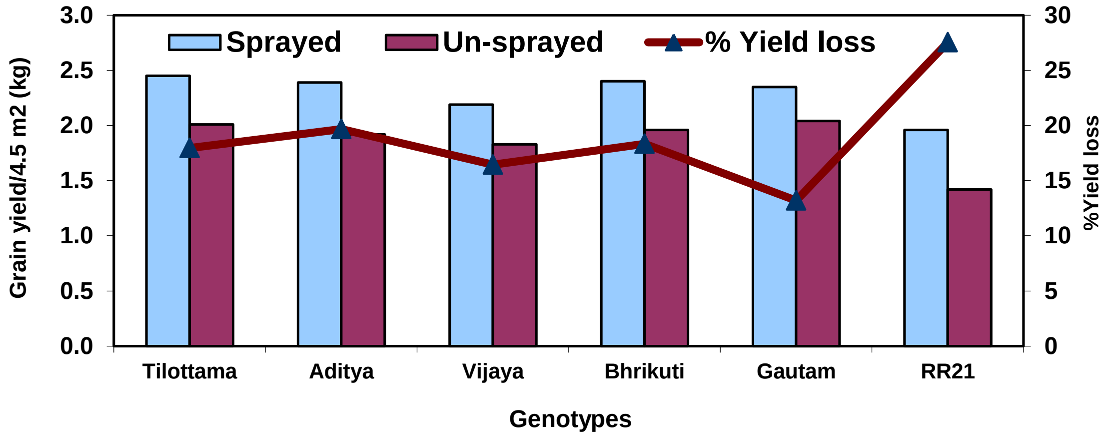

Figure 4. Yield performance of different genotypes at Chitwan in treated and non treated condition

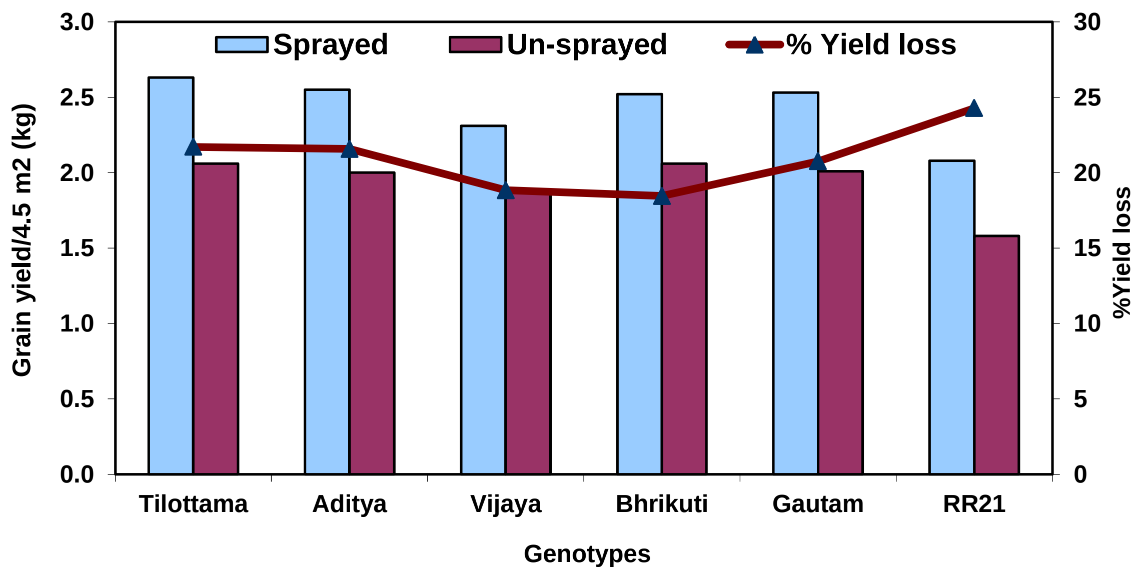

Figure 5. Combined effect of locations (Khumaltar and Chitwan) on yield of wheat genotypes

4. DISCUSSION

In the study, it was found that yield loss due to foliar blight disease estimated an average of 22% in wheat genotypes. The effect of disease on total yield reduction was more in plain area compared to hill area. Among the genotypes, old genotype RR 21 had high yield loss than other genotypes. The genotypes Bhrikuti showed better performance against the FB disease and yield gain up to 18.45% than non-sprayed fungicide. Similar result was also found that the genotype Bhrikuti has a yield gain of more than 13-39% over other susceptible genotypes UP 262, NL 297 and Sonaliak (Bhatta et al 1998). Likewise, a study also showed that wheat genotypes BL 4012 was found moderately resistant to foliar blight with significantly higher yield by 30% more compare to susceptible genotypes (Dangal et al 2016). Among the tested genotypes, the genotype Gautam was found more suitable in plain area than the mid hill region in term of disease severity and yield gain. The estimated yield gain in Gautam was ranges from 13-21%. However, other genotypes Tilottama, Aditya and Vijaya had no significant differ on severity of disease and yield gain at both locations. Response of wheat genotypes on foliar blight disease was difference with time and location. Wheat released genotypes such as WK 1204, RR21, Dhaulagiri, Bhrikuti, Gautam, NL1307, NL1367 were found highly susceptible to spot blotch disease at Khumaltar (PPD 2019). Similarly, NL 1278, NL 1342, NL 1362, NL 1345, NL 1344, NL 1298, BL 4868, BL 4820, BL 4919, BL 4928, BL

4939, BL 4941, BL 4946, WK 2602, WK 2891, WK 2978, WK 3164, WK 3165 and WK 3166 were recorded immune against spot blotch (PPD 2019). Likewise, the recent promising genotypes BL 4699, NL 1247 were found resistant to foliar disease and BL 4708, NL 1327 and BL 4707 were tolerant against the disease (Pandey et al 2018). In 2015, foliar blight was recorded moderate in mid hill especially in Khumaltar and Kathmandu valley. This could be due to climate change and rise in temperature and susceptible wheat genotypes and virulent pathogens (PPD 2016).

The incidence of disease and yield difference in plain and hill area attributed many abiotic factors such as time of planting, number of irrigation, weather condition and nutrient status of fields. The application of two irrigation cycles reduced leaf blight levels on the whole plant and on the flag leaf up to the dough growth stage increased grain yield, spikes m^{-2} and biomass by significantly reducing foliar blight compared with the non-irrigated plot. Foliar blight disease symptom starts from tillering stage and the symptoms gradually increase up to and rapidly develop after flowering, covering all above ground plants depending on genotype. Combined with high temperature during grain filling, the disease causes premature leaf firing of the crop resulting in reduced kernel weight and grain yield as a whole. Both the pathogens seem to be very opportunistic in nature and the disease tends to be more severe under stressed plant growth caused by poor nutrition, low soil organic matter and heat stress during later growth plant stages (Bhatta et al 1998). Furthermore disease severity largely depends on weather conditions, genotypes, time of planting and inoculum density. Grain infection is more severe when rain occurs during grain filling (Alam et al 1994). Singh et al 1998 found that higher seed rate (125 kg ha^{-1}), lower row spacing (15 cm), full fertilizer dose (120:60:60 N:P:K), higher number of irrigation applications and late sowing (20th December) increased foliar blight intensity compared with a lower seed rate (100 kg ha-1), wider spaced rows (23 cm), half fertilizer dose (60:30:30 N:P:K), a lower number of irrigation applications and timely sowing (30th November). Similarly, application of potash at 50 kgha-1 during field preparation was effective in suppression of spot blotch severity as compare to application of 25 kgha-1 (Bhandari 2013b).

The response of fungicide over the genotypes was also significant difference in severity of foliar blight disease. Reduction level of disease was also varying with the application of fungicide with different genotypes. Mahto 1995 found that Tilt (Propiconazole) was quite effective in reducing foliar blight disease and gain yield up to 16% by spraying three times at a rate of 0.5 L ha^{-1} in two weekly intervals. Another study in application of propiconazole @ 1.5 ml per litre of water fop two times at 70 and 85 days of seeding was found most efficient for suppression of the disease and increment of yield. In addition, the application of this fungicide reduced the spot blotch AUDPC by 58% when disease epidemic was high (Bhandari 2013a and Bhandari 2013b). However, there was no significantly yield gain on the application of fungicide among the genotypes. In previous study showed that there are varying the severity level of disease and total yield within the genotypes. The high yielding genotypes had lower AUDPC, Ning 8319 produced the highest yield (5,108 kg ha^{-1}) followed by Nepal 297 (Mahto 1995). Similarly, this study also found high yielding genotypes Bhrikuti and Gautam had lower AUDPC value.

5. CONCLUSION

The study leads to conclusion that fungicide Propiconazole is effective to minimize foliar blight disease caused by *Bipolaris sorokiniana* and *Pyrenophora tritici repentis* either individual or in combination of both pathogens and can be increased grain yield up to 22% in different wheat genotypes. The response of fungicide is varied with genotypes and location/altitude. Wheat genotype Bhrikuti is attributed higher grain yield with lower AUDPC of foliar blight disease as compare to other genotypes. The effect of foliar blight was observed more in plain area than hill region and grain yield was high in hill and low in plain due to impact of severity of disease in crops i.e., higher the disease lower the grain yield.

Conflict of interest

The authors declare that they have no conflict of interest.

Funding

There are no funding sources for this paper.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

Data and materials availability

All data associated with this study are present in the paper.

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