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RESEARCH ARTICLE

PERFORMANCE OF WHEAT GENOTYPES (*Triticum aestivum* L.) FOR FOLIAR BLIGHT RESISTANT AT LATE SOWN CONDITION IN NEPAL

*Basnet, R., Pokhrel, D. N., Pandey, D. and Dangi, S. R.

National Wheat Research Program Bhairahawa, Nepal

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ABSTRACT

Wheat is the third staple food crop of Nepal and it has many constraints for successful production among them time of planting and foliar blight are the major constraints. Previously foliar blight was the problems of only plan region but now days the severity of foliar blight gradually increasing year after year in hills of Nepal also. In order to identify the high yielder, late sown condition foliar blight tolerant wheat genotypes for Terai of Nepal, an experiment was carried out at National Wheat Research Program, Bhairahawa during 2013-2014. The experiment was designed in Alpha Lattice, composed of thirty wheat genotypes with two replication and six sub plots. Each plot was made eight rows of three meter long. Manually harvested middle six rows leaving one row both side as boarder row. Foliar blight was recording was done three time in seven days interval. Area under disease progress curve was calculated AUDPC). The lowest AUDPC was found Standard check (var. Gautam) with the highest yield 1909 kg-ha followed by 478.6 AUDPC of genotype NL 1202 which gave 1771 kg-ha yield.

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INTRODUCTION

Wheat is the world's most important crop after maize and highly significant in terms of food security. It contributes to about 41% of cereal calories from direct consumption worldwide (Shiferaw *et al*., 2013). It is used to make food, feed, beverages and biofuel (Lupton, 1987). Among cultivated wheat, bread wheat is one of the main staple foods in the world. Globally, its production is estimated to 680 million tons per year planted on about 225 million hectares (Sharma *et al*., 2013). Wheat is produced in a wide range of climates although it is most favorably adapted to cool, dry environments and least favorably adapted to warm, moist climates (Lupton, 1987). Wheat is the third most important cereal crop after rice and maize in Nepal. Wheat occupies 0.7 million ha area and produces 1.56 million tons of wheat with 2243 kg/ha productivity. Terai (plain area) of Nepal represents about 58% of total wheat area and contributes more than 71 % of total wheat production in the country, followed by hills 34% and mountain 8% of wheat area and contributes 25% and 4% to the total wheat production (Basnet *et al*., 2015). The average productivity of wheat in Nepal is very low than the potential yield. Various diseases and time of wheat planting are the major yield-limiting factors of wheat in Nepal.

***Corresponding author: Basnet, R.**
National Wheat Research Program Bhairahawa, Nepal.

Major diseases of wheat in Nepal are; foliar blight complex (Spot blotch caused by *Bipolaris sorokiniana* Sacc in Sorok. and Tan spot caused by *Pyrenophora tritici repentis* Died), Leaf rust (*Puccinia recondita tritici*), Stripe rust (*Puccinia striiformis*), Loose smut (*Ustilago segatum tritici*) and Powdery mildew (*Erysiphe graminis f. sp.tritici*). Leaf rust can cause up to 12% (Gharti, 1999) and more grain yield loss and has been prevalent in Terai and lower hills of Nepal. Severity of leaf rust has been decreasing due to the wide adoption of disease resistance varieties but foliar blight, the number one disease of wheat has been severe in plain areas and foothills and emerging towards mid hills and hills of Nepal. It causes up to 28% grain yield loss in farmers field condition (Mahato *et al*., 2000). Stripe rust is the major yield limiting disease of hills, which can reduce up to 30% in grain yield production (Upreti and Karki, 1988). Crop management, timely sowing, and good soil fertility are important components of integrated crop management for spot blotch. In Nepal, it has been shown that an application of 30 kg of K2O had a similar effect to one fungicide application (Sharma *et al.,* 2005). The fungus *Cochlibolus sativus* is the telemorph (Sexual stage) of *B. sorokiniana* (anamorph) which is the causal agent of wide variety of diseases. *B. sorokiniana* belongs to the division-Eumycota, subdivision-Deuteromycotina, class-Hyphomycetes, subclass-Sporomycetidae, order-Moniliales and family-Dematiaceae. After the discovery of perfect stage, *C. sativus*, the fungus was transferred under the subdivision-Ascomycotina, class-Loculoascomycetes, order-Pleosporales and family-Pleosporaceae. The genus *Cochliobolus* produces globose ascomata with a long cylindrical neck, obclavate cylindrical asci, and helically coiled filiform ascospores. Mycelium of *B. sorokiniana* is olive-brown and it produces light grey colonies at early stage of growth in potato dextrose agar medium, later turns into black to olivaceous black. Conidiophores are 6-10 × 110-220 µm, brown, erect, unbranched, single or clustered, septate. Conidia are 15-28 × 40-120 µm, straight to slightly curved, oblong, fusiform to broadly ellipsoid, olive brown to dark brown, tapered towards the end and have a prominent basal scar, smooth walled and having 3- 10 thick walled transverse septa (Jones and Clifford 1983). In the host tissue, it produces septate mycelium, which ramifies both inter- and intracellularly. Conidiophores are long, septate, simple, dark brown to olivaceous at the base and somewhat paler at the growing tip.

They arise in tufts through stomata, ruptured epidermis or wounds and produce conidia successively on new growing points. The points of attachment of successive conidia are marked by scars at the regular intervals on the condiophores. The perfect stage i.e., the ascigenous state was observed in the laboratory on natural media in the presence of opposite mating types, and was first described as *Ophiobolus sativus*. It was later renamed *C. sativus* Drechsler ex Dastur, 1942 (Dastur, 1942). Under natural conditions, the perfect stage was only found in Zambia (Raemaekers, 1988). Foliar blight development and severity of the disease is directly related to the minimum tillage or surface seeding, irrigation, low soil fertility, sowing density, crop growth stage, late rain during crop cycle, heat stress during grain filling as a result of late planting, high temperature in the field and relative humidity favoring long duration (>12 hours) of leaf wetness (Duveiller *et al*., 2005). Even at the end of the monsoon and in absence of rainfall, high relative humidity arising from high levels of soil residual moisture along with foggy days allows long hours of wetness on leaf blades that can last until late January in Indo-Gangetic Plains, creating ideal conditions for the establishment and multiplication of wheat pathogen (White and Rodriguez-Aguilar 2001). In Brazil, Reis (1991) suggested that, for foliar blight outbreaks to occur, wheat leaves must remain wet for >18 h at a mean temperature of 18˚C or higher.

Moderate to warm temperatures (18˚C to 32˚C) favours the growth of *B. sorokiniana*. In Asia, the infection was more rapid and more severe at 28°C than at lower temperature (Singh *et al*., 1998). The higher values of AUDPC/day or AUDPC/degree day under late-sown conditions are most likely caused by heat stress, which enhanced HLB development (Sharma and Duveiller 2003). Delayed seeding for wheat, grown after rice in eastern India and Nepal also results in higher losses of grain yield and total kernel weight due to foliar blight (Duveiller *et al.,* 2005). Rice wheat is the predominated cropping pattern of Terai (Plain) of Nepal. Late sowing of wheat in Terai is very common due to many factors viz. excess or loss of soil moisture just after rice harvesting, delay in rice harvesting due to late maturing varieties of rice or shortage of field man power during rice harvesting time (Pokhrel *et al*., 2013). Late sowing wheat is always exposed to high temperature during reproductive and grain filling stages, which forces the premature ripe. High temperature at the reproductive age hastens spike development resulting in abortion of late forming florets and reduction in potential kernel number (Pokhrel *et al*., 2013). Several chemical, cultural and physical methods have been developed to reduce the intensity of these diseases but none of them have been found very for long time and economic. Use of disease resistant variety is one of the best and economic methods of disease management. Therefore the present study was carried out to identify the best disease resistant and heat tolerant genotypes with the following objectives.

- To find out the incidence, severity of foliar blight and yield potential of wheat genotypes in late sown condition.
- To identify the foliar blight tolerant wheat genotypes in late sown conditions.

MATERIALS AND METHODS

The experiment was conducted at National Wheat Research Program, Bhairahawa. This experimental site situated in Padsari Village Development Committee of the Rupandehi district of Nepal which is about 3 kilometer away from district headquarters. Geographically, the station is located at an altitude of 105 m with m above mean sea level with 27.54567' North latitude and 83.46084 East longitudes. The details of the meteorological information were shown below (Figure 1). The planting materials were selected at National Wheat Research Program, Bhairahawa, Rupandehi. The experiment was laid out in the Alpha Lattice Design with two replications. Thirty wheat genotypes (treatments) were explored in this experiment. The experiment was planted at 26th December. Each treatment was planted at eight rows of three meter long (12 m^2), the cropping geometry 25 cm apart row to row distance with continuous line sowing. Chemical fertilizer 100:60:40 kg NPK^{-}ha was applied, half dose of nitrogen and applied at the time of planting and remaining half dose was applied at the time of intercultural operation. Severity of disease was recorded by visually assessing with double digit method. Foliar blight severity can be visually scored for each plot at weekly intervals using the double-digit scale (00-99) developed as a modification of Saari and Prescott's severity scale to assess wheat foliar diseases (Saari and Prescott, 1975; Eyal *et al.,* 1987). The first digit (D1) indicates the disease progress in height and the second digit (D2) refers to severity measured the diseased leaf area. For each score, percentage of diseased leaf area (%DLA) was estimated based on the following formula:

% DLA = ((D1/9) x (D2/9) x 100)

Individual scores were recorded over a three-week period. The Area Under Disease Progress Curve (AUDPC) was calculated using the percent severity estimates corresponding to the three to four ratings as outlined by Das et al. (1992) and shown below:

$$AUDPC = \sum_{i=1}^{n-1} \left[(X_i + X_{i+1}) / 2\right] (t_{i+1} - t_i).$$

Where, xi = disease severity on the ith date, ti = ith day, and n = number of scoring dates. The AUDPC measures the amount of disease as well as the rate of progress, and has no units.

RESULTS AND DISCUSSION

Days to heading

Days to heading was recorded when it was observed 50 percent of the total population in a plot.

Table 1. The mean grain yield, yield attributing parameters and AUDPC value

Genotypes	Heading (Days)	Maturity (Days)	Plant Height (Cm)	Spike/m^2	Kernel/Spike	Test weight (gm)	AUDPC	Grain Yield (Kg/ha)
BL 4535	73.0	98	90.1	248	191	38.02	666.5	1779
BL 4468	76.0	100	97.3	265	171	35.49	686.4	1460
BL 4469	74.0	100	95.8	294	234	31.28	897.9	1338
BL 4472	73.0	100	87.7	278	235	29.69	942.8	1238
BL 4473	75.5	100	116.1	323	197	29.85	971.4	1384
BL 4477	74.5	100	115.2	344	227	33.14	484.8	1670
BL 4480	75.5	99	112.7	313	222	26.66	899.0	1459
BL 4488	73.0	98	115.0	294	213	36.92	706.0	1473
BL 4499	73.0	100	109.6	239	171	38.02	716.1	1654
BL 4507	74.0	99	92.5	344	220	28.49	774.2	1541
NL 1198	75.0	100	89.7	350	240	23.62	989.9	1425
NL 1199	74.0	100	95.6	267	223	29.92	658.5	1506
NL 1200	75.0	100	94.5	410	198	21.49	826.0	1341
NL 1201	74.0	99	94.0	287	251	27.09	770.8	1443
NL 1202	73.5	98	89.1	301	241	32.64	478.6	1771
NL 1203	75.0	100	94.6	293	205	25.25	704.9	1701
NL 1204	75.0	100	83.6	304	225	25.4	1010.0	1295
NL 1205	76.0	100	81.1	279	310	26.4	848.4	1420
NL 1206	73.0	99	89.3	241	251	26.63	554.7	1644
NL 1207	75.5	100	90.3	322	239	24.67	867.7	1545
NL 1208	76.0	100	88.8	386	190	25.17	878.5	1428
NL 1209	76.0	100	84.7	377	250	22.73	925.3	1356
NL 1210	74.5	98	99.7	384	228	24.65	574.8	1648
NL 1211	74.0	98	89.2	381	183	30.36	672.2	1537
NL 1212	73.0	98	95.5	248	226	28.49	707.2	1616
NL 1213	74.0	99	77.3	231	239	28.66	693.5	1650
NL 1214	75.5	100	82.7	282	254	26.62	611.8	1750
NL 1215	74.5	99	84.1	324	198	26.52	763.7	1596
Bhrikuti	73.0	99	86.4	392	263	26.76	758.9	1650
Gautam	73.0	100	97.2	371	227	33.87	432.5	1909
Grand Mean	74.4	99.2	94.0	312.1	223.9	28.8	749.1	1541.0
F -test	HS	HS	HS	HS	HS	HS	HS	HS
$LSD_{(0.05)}$	0.73	1.20	6.41	73.57	54.66	2.41	254.95	284.04
CV%	0.49	0.60	3.41	11.79	12.21	4.18	17.02	9.22

HS=highly significant at 5%
AUDPC= Area Under Disease Progress Curve

Table 2. Simple linear correlations of AUDPC value with yield and other yield attributing parameters

	Days to Heading (Day)	Days to maturity (Day)	Plant height (cm)	TKW (gm)	AUDPC
Days to maturity(Day)	0.5121				
Plant height (cm)	-0.0939	0.0346			
TKW (gm)	-0.5199	-0.1810	0.4400		
AUDPC	0.4467	0.3573	-0.1124	-0.4407	
Grain yield (Kg/ha)	-0.4023	-0.3403	0.0002	0.3565	-0.8366

Days to heading was found highly significant (*P≤0.05*) among the tested genotypes (Table 1). The first heading was observed in BL 4535 followed by BL 4472, BL 4488, BL 4499, NL 1206 and NL 1212 (73 days). Difference among wheat genotype in the duration of the period between sowing and heading are largely governed by their sensitivity to photoperiod and vernalisation (Slafer *et al.,* 1995). Spot blotch severity increases with the advancement of growth stages (Chaurasia *et al.,* 2006). But short and early genotypes appear distinctly more diseased than others; further studies are needed to understand the effect of earliness and plant height on disease development or possible escape (Duveiller *et al.,* 1998).

Days to maturity

Days to maturity was recorded when 75 percent populations showed yellowish peduncle. Days to heading was found highly significantly differ (*P≤0.05*) among the tested entries (Table 1).The early maturity were observed in BL 4535 followed by BL 4488, NL 1202, NL 1210, NL 1211 and NL 12012 (98 days). Maturity duration of any variety plays an important role in the acceptance or rejection of the genotypes.

In Nepal, farmers are most frequently reluctant to accept a variety which has better yields but late in maturity (Tiwari *et al.,* 1995). There is no negative correlation was found in days to maturity and AUDPC (Table 2). However, the highest grain yield was obtained by genotypes BL 4535 (1779 kg-ha).

Plant Height

Plant height was measured at the dough stage (Zadoks growth stage 87) (Zadoks et al., 1974). The plant height was found highly significantly differed (*P≤0.05*) among the tested genotypes (Table 1). Plant height was negatively correlated (-0.1124) with AUDPC (Table 2). The best leaf blight-resistant wheat in South Asia were reported to be late and tall, two less desirable agronomic characters and breeders doubted the possibility to develop early maturing resistant genotypes. Studies reported less spot blotch resistance in short plants with early maturity (Dubin *et al.,* 1998). The tallest genotype was found BL 4473 116.1 cm followed by BL 4477, BL 4480, BL 4488 and BL 4499 with AUDPC 484.8, 899.0, 706.1 and 716.1 respectively. However, BL 4473 was found highest genotypes and its AUDPC value was also high (971.4), although tall and early genotypes appear distinctly more diseased, further studies are needed to understand the effect of earliness and plant height on disease development.

Spike per meter square and kernel per spike

Spike per meter square s found highly significant (*P≤0.05*) among the tested genotypes. The mean spike per meter square was 312.1 and the highest number was found in genotype NL 1200 but it showed more AUDPC value (826.0). Similarly, kernel per spike was also found significantly different (*P≤0.05*) among the tested genotypes. The mean kernel per spike was 223.9 and the highest number of kernel was found in genotypes NL 1205 (310) and followed by NL 1204, NL 1201 and NL 1206. Grain yield in wheat can be analyzed in terms of three yield components, number of spikes per unit area, number of kernels per spike and kernel weight (Table 1). The number of spikes per plant was affected least by drought stress and the number of grains per spike was affected most (Ehadaie *et al.,* 1988). Under different drought treatments, the kernels per spike and spikes per square meter were the yield components most sensitive to drought while kernel weight remains relatively stable (Zhong-hu and Rajaram, 1994). Several studies have indicated that variation in grain yield between moisture regimes was predominantly associated with variation in spikes per square meter and kernels per spike (Simanae *et al.,* 1993).

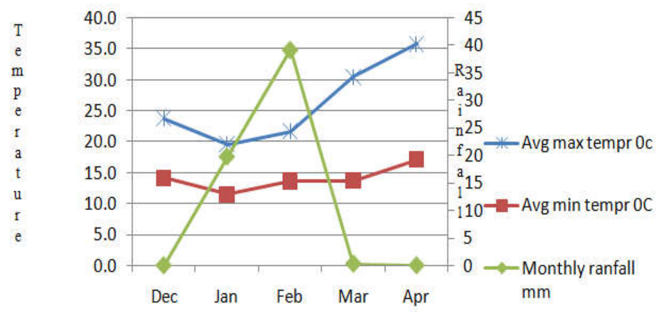

Figure 1. Monthly meteorological information during the experiment

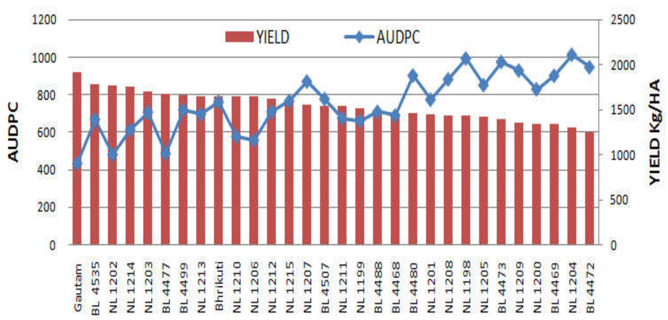

Figure 2. AUDPC and grain yield of the tested genotypes

Test weight (1000 kernel weight)

Test weight of the wheat genotypes increase the grain yield higher than other yield attributing parameter. The analysis of variance revealed that the test weight were highly significant (*P≤0.05*) among the tested genotypes. The highest test weight were found in genotypes BL 4535 (38.02gm) and BL 4499 (38.02 gm) followed by BL 4488 (36.92 gm) and BL 4468 (35.49). The genotype BL 4535 had 666.5 AUDPC value and gave 1779 kg-ha grain yield (Table 1). The test weight was negatively correlated with AUDPC (Table 2). The environmental stress or diseases stress test weight reduced significantly ultimately reduced the grain yield.

Grain Yield

The grain yield was found highly significant (*P≤0.05*) among the tested genotypes. The genotypes BL 4535 gave 1779 kg-ha yield followed by NL 1202 , NL 1214, NL 1203, BL 4477 and BL 4499 with yield 1771, 1750, 1701, 1670 and 1654 kg-ha respectively in late sown stressed condition (Table 1). The linear correlation of grain yield and AUDPC was negatively correlated (Table 2). Similar results was also reported in Zambia, yield and HLB were negatively correlated (Raemakers, 1988). The estimated contribution of stored assimilates to grain yield in wheat depends on the genotype, experimental conditions, and the method of measuring stored carbohydrates. Stored reserves and their contribution to grain can be estimated by measuring post-anthesis changes in inter node dry matter (Ehdaie *et al.,* 2006), or/and changes in internode water-soluble carbohydrate content during the grain-filling period or estimated by difference in canopy dry weight at anthesis and at maturity excluding the grains (Fischer, 1980). The assimilate supply problem may be compounded by further reductions in photosynthesis due to water stress, suggesting that the reduction in seed number caused by stress at this critical period is proportional to the reduction in leaf-area development, and hence in available assimilate during the approximately 25 days before anthesis (Fischer, 1980).

Conclusion

The findings of the study have implication for development of high yielding and foliar blight tolerant/resistant wheat cultivar for general cultivation in Nepal and similar condition of world. Varietal resistant is environmental friendly and economical means of getting better yield to feed the world population. The genotypes NL 1202, BL 4477, NL 1206 and NL 1210 may be utilized by breeder for resistance transferred using cyclic breeding program into commercial varieties or release to minimize the loss due to foliar blight in late sown condition of Nepal or similar environment.

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