Seasonal Variations in the Occurrence of Wheat Stripe Rust in Bale Highlands

Bekele Hundie, Shambel Kumbi and Dereje Hailu
Oromiya Agricultural Research Institute,
Sinana Agricultural Research Center
P. O. Box 208 Bale-Robe, Ethiopia

Abstract

Wheat is produced in two equally important seasons in Bale highlands of Ethiopia which are locally called *bona* and *ganna*. Stripe rust (*Puccinia striiformis*) variability by season was investigated using rust trap nursery (1996-2000), on-farm rust survey (1996-1998) and rust urediospores trapping (1998-2000). The results showed that b*ona* season was favorable for Stripe rust development. The optimum temperature range for Stripe rust sopre germination and rapid disease development also prevailed in this season. As a result, Stripe rust severity in the field and inoculum load in the air was significantly higher during *bona* than *ganna* season.

Introduction

Stripe rust (*Puccinia striiformis*) of wheat is normally confined to high elevation and cooler climates (Wiese 1987). Stewart and Dagnachew (1967) were the first to report stripe rust in Ethiopia. Since then, several workers have described the importance of the disease in Ethiopia (Getaneh 1990, Getaneh et al. 1990, Getinet et al. 1990, Mesfin & Dereje 1990, Lemma et al. 1997). Yield losses ranging from of 20-96% due to stripe rust were reported in different parts of Ethiopia (Eshetu 1985, Mozgovoy 1987). Stripe rust outbreak is frequent in Bale-Arsi region during *ganna* (March-July) and *bonna* (late July-December) seasons (Getaneh 1990) The wheat growing area during *ganna* season in Bale highlands was 28,870ha (CSA 1998a) compared to 74,520ha in *bona* in 1998 (CSA 1998b). *Ganna* wheat production is increasing in Bale highlands, however, there is no quantitative information on the incidence and economic influence of wheat rusts for *ganna* seasons in Bale highlands. This paper presents the relative importance of Stripe rust on wheat during *bona* and *ganna* seasons in Bale highlands.

Materials and Methods

Rust Trap Nursery

A rust trap nursery consisting of 55-186 (in *ganna*) and 185-193 (in *bona*) consisting of bread (*Triticum aestivum* L.) and durum wheat (*T. durum* L.) genotypes having different degree of resistance and stripe rust differentials was planted at Sinana from 1996-2000. Each genotype were planted in a non- replicated nursery in two rows of 1m long and 0.4m wide plots. A seed rate of 150 kg/ha was used. At planting, 41-46kg N-P_2O_5 per hectare was applied. Weeds were removed manually as needed. Stripe rust severity and reactions were recorded using the modified Cobb scale (Peterson et al. 1948). Terminal rust severity was averaged for each bread wheat and durum wheat genotypes and used to measure rust variability during the two seasons. Percentage of genotypes infected and the severity level of stripe rust differentials were used to estimate the level of virulence in this pathogen.

Stripe rust

survey

Field rust surveys were conducted on 66, 51 and 114 farmers' fields in *ganna*, and on 165, 59 and 165 farmers' fields in *bona* seasons in 1996, 1997 and 1998, respectively, in Bale highlands. Rust incidence and severity were recorded at five random spots and were used to calculate average values. However, only percent range of infected field severity and mean of severity of 1996 and 1998 were used to compare the disease situation during the seasons.

Rust spore trap

Number of urediospores was monitored from 1998 to 2000 in both cropping seasons using Burkard 7-Day Volumetric Spore Trap (Burkard Scientific Instrument Rickmanswork, Hertfordshire). The capacity of the orifice was 2mm X 14mm and positioned at 1.90m from the surface of the ground. Air was drawn at the rate of 10 liters per minute. The tape was surfaced with a mixture of 35g gelvatol (1000ml distilled water, 50ml glycerol and phenol). Daily spores were determined on the basis of 48mm of exposed tape per day. The 48mm exposed tape was divided into five sections and mounted on a light microscope slide to inspect spores in three fields of each section with a magnification of 400X. The actual area of 15-magnification fields was 2.3866mm^2. The number of spores counted on 2.3866mm^2 was represented by 'X'. Then, total spores trapped (T) were estimated from the total area, 48mm x 14mm = 672mm^2 of adhesive tape exposed to spores in a day by the formula, T= 'X' x 672mm^2 / 2.3866mm^2. Given, 10 liters of air was sucked per minute, and 1m^3 of air is equal to 1000liters, the amount of air sucked per day was determined to be14.4 m^3. Then given spore sampler efficiency of 70%, the adjusted number of spores (A) per m^3 of air was estimated by the formula, A='X' x 672mm^2 x 100/ 2.3866mm^2 x14.4 x70. Maximum and minimum temperatures and precipitation were collected from Sinana Research Center weather station.

Results

Stripe rust appeared early in *bona* and *ganna* seasons but highly variable with the seasons whenever it occurred in the nursery. Generally, the disease was endemic and more sever to *bona* season, whereas it occurred but least severe during *ganna* season (Table 1). *Ganna* season was rust free in the 1996, 1997 and 2000 cropping seasons. The percentage of infected genotypes was higher in *bona* than in *ganna* season. Among the infected genotypes, during 1996 to 2000, the majority (53.5-71%) exhibited a stripe rust severity range of 21-100% in *bona* season, whereas only few genotypes (0.5- 4.8%) showed a rust severity of more than 20% in *ganna* season. Among the differentials that showed > 20% were Morocco, Avocet susceptible, Aroona, Corella, Millew and Fed 4/KVZ (Table 2). On the other hand, both the recent or old commercial cultivars released in Ethiopia were almost Stripe rust free in the *ganna* season but most genotypes were susceptible to stripe rust in the *bona* season (Table 3). During 1998 to 2000 bonna seasons, the recently released bread wheat cultivars (Wabie, Kubsa, Abola and Katar) were susceptible for the first time.

Table 1. Percentage and number of genotypes infected by stripe rust at Sinana during *ganna* and *bona* seasons, 1996-2000

Season	Test year	No. of genotypes tested	% infected genotypes	No. of genotypes in severity classe s				
				1-10	11-20	21-30	31-40	41-100
Ganna	1996	55	0	0	0	0	0	0
	1997	178	0	0	0	0	0	0
	1998	184	36.4	61	5	0	1	0
	1999	186	60.0	74	21	6	2	1
	2000	184	0	0	0	0	0	0
Bona	1996	187	89.3	43	24	43	29	28
	1997	185	89.2	46	7	14	61	37
	1998	188	92.0	31	23	19	44	56
	1999	186	95.2	28	24	28	28	69
	2000	193	94.3	24	21	22	79	36

Table 2. Severity of stripe rust on different differentials during *ganna* and *bona*seasons at Sinana from 1996-2000

Variety	Yr gene	ganna season					bona season				
		1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
Aroona	*	0	0	20MS	60S	0	70S	60s	80S	0	0
Aroona *5/Yr1	1	-	-	0	0	0	-	0	0	80S	70S
Klyansona	2	-	-	0	10S	0	-	60s	70S	60S	70S
Trticum spelt album	5	-	-	-	0	-	0	-	-	0	TMS
Arona *6/Yr5	5	-	-	TMR		0	-	0	0	10MS	40S
Yr5/6* Avocet s	5	-	-	0	0	0	-	5R	0	TMR	0
Morocco	NG	0	-	0	40S	0	80S	80S	90S	90S	100S
Yr5/6* M2435	5	-	-	5MS	10S	0	-	40S	40S	30S	30S
Millewa	6	0	0	5MR	30S	0	60S	60S	80S	80S	80S
Oxley	6+	0	0	TMS	15MS	0	20S	40MS	40S	30S	40MS
Corella	6+7	-	-	TMR	40S	0	-	80S	80S	80S	70S
Cranbrook	*	-	-	0	TMS	0	-	40S	50S	30S	50S
Arona *6/Yr8	8	-	-	0	10S	0	-	40MS	25MS	30S	30MS
Yr8/Avocet S	8	-	-	0	0	0	-	5MS	0	0	0
FED 4/KUZ	9	0	0	TMS	30S	0	40S	40S	50S	30S	40S
Yr10/6* M2435	10	-	-	0	0	0	-	5MR	0	0	0
V763-259-WB-2	15	-	0	0	0	0	TMR	5MR	0	0	0
Yr15/6* Avocet S	15	-	-	0	0	0	-	5MR	0	0	0
Arona *3/Yr15	15	-	-	0	10MS	0	-	5R	0	0	0
Arona *6/Yr17	17	-	-	0	0	0	-	0	0	TMS	0
Cook	18	0	0	0	0	0	10MS	5MR	15MS	25S	25S
Jupateco s	*	-	-	0	10MS	0	-	40MS	80S	60S	80S
Jupateco r	18	-	-	0	TMS	0	-	40S	70S	40MS	80S
Avocet resistant	A	0	0	TMR	10MS	0	60MS	60S	30S	30S	40S
Avocet susceptible	NG	0	0	40S	30S	0	70S	60S	80S	80S	80S
M-2435*6/yr9	9	-	-	15S	TMS	0	-	40S	40S	30S	40S
Condon (resistant)	A	0	0	-	-	-	30MS	-	-	-	-
Gather resistant	7	0	0	-	-	-	40MS	-	-	-	-
Aurdra/7* warga 1/14*arona	9	0	0	-	-	-	60S	-	-	-	-

*NG = no resistance gene, * = unknown Yr-gene, - = Not included*

Table 3. Level of stripe rust infection on some recent and old commercial cultivars at Sinana during short and main seasons of 1996-2000

Cultivar	Year of release	Rust severity %									
		ganna season					bona season				
		1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
K6290-bulk		0	0	0	0	0	5	40	30	30	50
Dereselign	1974	0	0	0	0	0	30	60	35	40	60
Batu	1984	0	0	0	0	0	5	60	40	40	40
Dashen	1984	0	0	0	0	0	20	60	40	70	40
Gara	1984	0	0	1	0	0	10	80	40	40	50
Lakech	1970	0	0	0	0	0	50	60	50	50	60
Pavon-76	1982	0	0	1	1	0	15	30	30	60	40
Galema	1995	0	0	0	0	0	0	0	0	1	1
Wabie	1994	0	0	0	0	0	0	0	60	60	40
Kubsa	1995	0	0	0	0	0	1	0	10	20	40
Tusie	1997	0	0	0	0	0	1	5	30	15	15
Abola	1997	-	0	0	0	0	0	5	40	40	30
Mitikie	1994	-	0	0	0	0	1	5	10	10	15
Megal	1997	-	0	0	0	0	0	5	15	15	40
K6295-4a	1980	0	0	1	0	0	5	10	20	20	25
ET-13	1981	0	0	1	0	0	1	10	10	15	50
Katar	1999	-	-	0	0	0	-	0	40	30	50
Morocco	Check	0	0	10	40	0	90	80	90	90	100

- = Not included

Sasonal status of the stripe rust was not affected due to wheat types (bread wheat and durum wheat). It remained low in *ganna* and high in *bona* seasons both on bread wheat or durum wheat. However, within *bona* and *ganna* seasons, bread wheat was more vulnerable to Stripe rust than durum wheat (Table 4).

Field disease survey results of 1996 and 1998 revealed that Stripe rust occurred least and were not important in *ganna* season but most severe and widely distributed in *bona* seasons in all districts of Bale highlands (Table 5).

Spore load in the air was significantly abundant during July to January in *bona* season all the years. However, it became lower in August compared to the preceding and later months. Consistently over the years, the highest spore concentration reached in October and November (Fig.1).

Table 4. Average stripe rust severity on wheat genotypes at Sinana during *ganna* and *bona* seasons of 1996-2000

Season	Wheat type	Stripe rust severity (%) by test year				
		1996	1667	1998	1999	2000
Ganna	Bread wheat	0.00	0.00	1.74	7.53	0.1
	Durum wheat	-	-	0.07	2.40	0.00
Bona	Bread wheat	26.76	34.39	37.67	40.02	35.45
	Durum wheat	-	11.67	14.67	25.33	35.33

- = Not included

Table 5. Prevalence and severity of Stripe rust in different districts of Bale highlands during 1996 and 1998.

Districts	Parameter	ganna season		bona season	
		1996	1998	1996	1998
Adaba	Fields surveyed	Um	Um	34	23
	Prevalence	Um	Um	17	15
	Severity range	Um	Um	1-60	1-60
	Severity mean	Um	Um	36.0	21.1
Dodola	Fields surveyed	Um	Um	10	30
	Prevalence	Um	Um	6	23
	Severity range	Um	Um	1-25	1-60
	Severity mean	Um	Um	10.3	27
Goba	Fields surveyed	-	5	10	9
	Prevalence	-	0	8	4
	Severity range	-	0	1-20	1-15
	Severity mean	-	0	6.2	5.7
Agarfa	Fields surveyed	7	13	13	7
	Prevalence	0	0	12	3
	Severity range	0	0	1-60	1-20
	Severity mean	0	0	13.4	8.7
Sinana-Dinsho	Fields surveyed	23	29	75	38
	Prevalence	0	3	71	28
	Severity range	0	1	1-70	1-60
	Severity mean	0	1	15.3	25.8
Goro	Fields surveyed	7	10	4	14
	Prevalence	0	0	4	3
	Severity range	0	0	1-15	30-40
	Severity mean	0	0	7.8	33.3
Gindhir	Fields surveyed	11	17	-	14
	Prevalence	0	0	-	10
	Severity range	0	0	-	5-40
	Severity mean	0	0	-	19.5
Gassera-Golocha	Fields surveyed	18	40	18	30
	Prevalence	0	5	11	15
	Severity range	0	1-20	1-10	1-70
	Severity mean	0	6.6	4.1	26.2

Um = Districts that do not have short season (unimodal)

- = Not surveyed in this year

Discussion

Spores were found across years and seasons (Fig. 3). Mengistu et al. (1991) also reported the presence of rust spores in the atmosphere from March until the year-end at Ambo. Since obligate parasite can not stay alive out of its host for a long time, sources of spores across years and seasons could be on volunteer crops or different grasses in highlands of Bale or at other high altitudes of the country. Nevertheless, spore movement from the neighboring countries into Ethiopia could not be ignored due to the similarities among race patterns within the East Africa, especially between Kenya and Ethiopia (Stubbs 1988). Earlier studies confirmed the occurrence of rust on wheat and barley at Ginchi and Sheno (Shewa) and in highlands of Arsi region during the month of February (Mengistu et al.

February (Mengistu et al. 1991). Spore concentration was high in *bona* season, most probably because of the favorable factors for rust infection, sporulation and spore (inoculum) dissemination in the field as well as spore movement in the air. Moreover, wheat cultivation during *ganna* season could be a viable inoculum source for *bona* season although the rust itself is not so important in the short season.

The maximum mean temperature during September to November did not exceed 20^{0}C (Fig. 2). This temperature range is optimum for rapid development of stripe rust (Wiese 1987, McIntosh et al. 1995). However, the maximum temperature in the rest of the months in both the seasons exceeded the afor-mentioned optimum temperature. The minimum temperature in both seasons was within the range of the optimum temperature range suited for Stripe rust spore germination (3 - 15^{0}C) (Wiese 1987) or rapid development (Wiese 1987, McIntosh et al. 1995). The rainfall pattern of the area was erratic in distribution in both seasons (Fig. 1). However, most probably the frequency of favorable environments such as longer duration of foggy and cloudier sky in *bona* season raised the humidity and thereby suited for the formation of free moisture on the plant surface. These conditions favored for an optimum rust spore germination and infection followed by the rapid rust development in *bona* season.

Stripe rust was not only endemic during *bona* season but also it was most severe on large number of wheat genotypes during this season. On the contrary, this rust was least frequent and only occurred on few genotypes in *ganna* season. Both the old and recently released commercial cultivars tested in *ganna* season were almost rust free in all years. The plausible reason for most cultivar infection in *bona* than in *ganna* season attributed to the presence of a wide virulence spectrum in *Puccinia striiformis* populations and due to the fast pathogen evolution of many races in *bona* season. According to Masresha (1996), ninety Stripe rust races were detected between 1975 and 1988 among which races 0E0, 2E0, 4E0 and 6E0 were dominant in Bale highlands. Most of the wheat cultivars, including old and recent cultivars that were rust free in *ganna* season were found to be susceptible during *bona* season, suggesting the pressure of a narrow virulence spectrum in *ganna* season. As a result, growing of wheat cultivars with few effective stripe rust resistance genes for a longer duration might be possible in this season. In addition, stripe rust resistance genes that became ineffective under *bona* season could be effective under *ganna* season provided that the present farming system, production environments and the pathogen virulence status are remained unchanged.

The low rust severity recorded under on-station as well as on-farm showed that stripe rust is not an economically important disease to wheat in *ganna* season in the Bale highlands. Conversely, the high level of stripe rust severity recorded revealed the economic importance of the disease during *bona* season in Bale. The frequent occurrence and variability of stripe rust in most bread wheat cultivars during *bona* season asserted the broad virulence variability of stripe rust population and its economic significance in the Bale highlands.

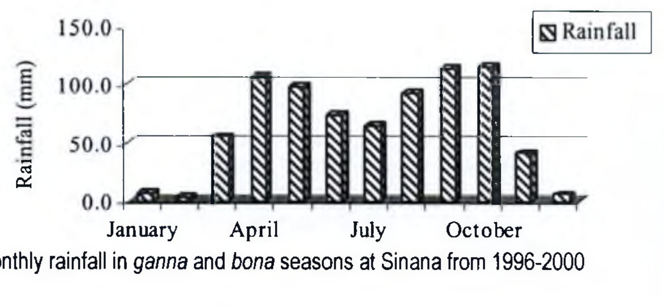

Fig.1 Monthly rainfall in *ganna* and *bona* seasons at Sinana from 1996-2000

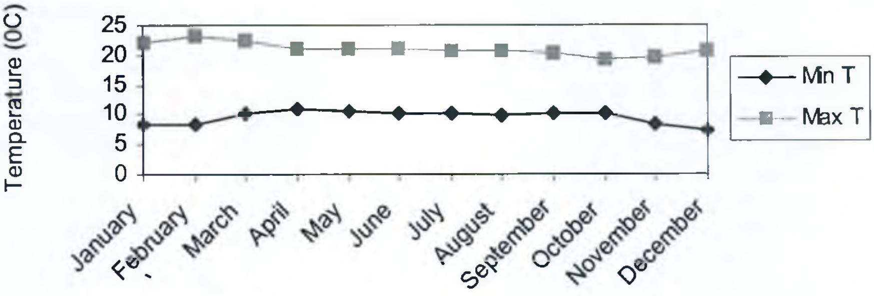

Fig. 2. Average maximum and minimum temperature at Sinana from 1996-2000

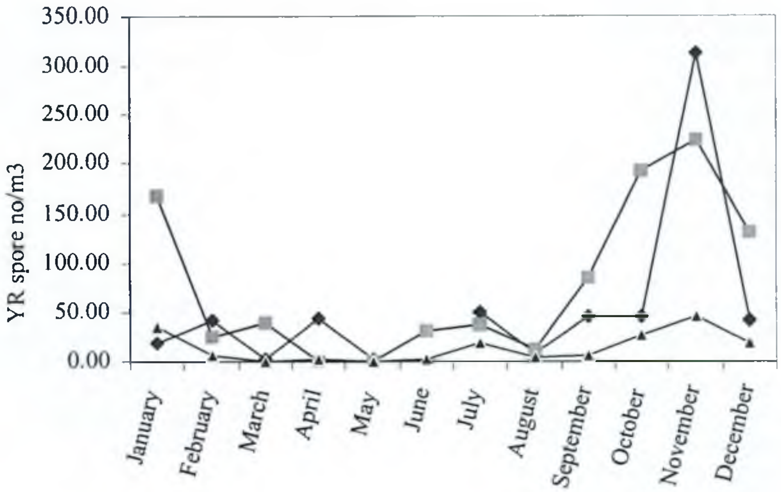

Fig. 3. Stripe rust spore concentration in the air at Sinana from 1998-2000,

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