International Scholars Journals

African Journal of Crop Science ISSN 2375-1231 Vol. 4 (2), pp. 280-285, February, 2016. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Yellow rust (*Puccinia striiformis*) epidemics and yield loss assessment on wheat and triticale crops in Amhara region, Ethiopia

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Accepted 09 October, 2015

The impact of yellow rust on grain yield and thousand grains weight was assessed by superimposing trials on farmer's fields in three administrative zones in Amhara region. Paired (fungicide sprayed and unsprayed) plots with two replications were used in three districts with three localities each. Yellow rust resulted in a significant (P<0.05) reduction in grain yield (34%) and thousand seed weight (16.7 %) in the region. Grain yield losses of 47.2% and 32% were observed in the worst scenario in north Shewa and in east Gojam zones, respectively. Grain yield loss was lowest (28%) for south Gondar zone. The wheat cultivars suffered the highest yield and seed weight reductions as compared to triticale. Grain yield reductions of 41.5% and 43.6% were recorded on cultivars HAR 1685 and HAR 604, respectively while the triticale cultivar, Logaw Shibo showed a 23.8% reduction. Reductions in thousand seed weight were 19.2% for the cultivar HAR 1685 and 21.7% for HAR 604. The seed weight loss of triticale was only 8.5%. This data indicates that the effect of yellow rust on yields of wheat and triticale was significant in the region and of course spraying chemicals did significantly reduce the impact of the disease.

Key words: Grain yield, thousand grain weight, disease epidemic, disease incidence, disease severity.

INTRODUCTION

Wheat is one of the major cereals in Ethiopia. It accounted for about 1.6 million hectares (13% of national cereal acreage) in the 2013/2014 cropping season; fourth in area coverage and third in amount of grain production (3.9 million tons) following maize and tef (CSA, 2014). Wheat is mainly grown in Oromia, Amhara, SNNP, and Tigray regions of Ethiopia. Amhara region is the second largest producer next to Oromia region. According to CSA (2014), the Amhara region shared 33% (529,648 ha) of the total wheat area and 28% (1.1 million tons) of grain production in the country.

In spite of the enormous economic significance of the crop in the country, its production and productivity is limited by various biotic and abiotic environmental factors, disease prevalence being one of the major constraints (Hailu et al., 1991).

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Quantifying the distribution and damage caused by a disease is important to set priorities in the disease management strategies(Madden and Hughes, 1995).Dagnatchew (1967) reported that the rusts, as a group, were the most important diseases of wheat including yellow rust (*Puccinia striiformis*). Yellow rust incidence in Ethiopia was first reported in the early 1940's and since then it is becoming more devastating and wide spread following the expansion of semi-dwarf improved wheat cultivars (Hailu et al., 1991). Yield losses of up to 58% were reported in the 1998 and 1990 yellow rust outbreak in the south eastern highlands of the country(Badebo and Bayu., 1992). Yellow rust is more severe in altitudes higher than 2100 meters above sea level (Geremew et al., 1988; Hailu et al., 1991; Mengistu et al., 1991). Yellow rust can cause yield losses of up to 100% on susceptible cultivars if infection occurs very early in the crop development stage and the disease continues to develop during the growing season(Afzal et al., 2007; Khanna et al., 2005). The impact of yellow rust varies depending upon the susceptibility of cultivar, earliness of the initial infection, rate of disease development and duration of the disease (Chen, 2005).

Yellow rust epidemics are becoming more frequent in Ethiopia. According to Mozgovoy (1987), epidemics of yellow rust occurred in 1977, 1980-83 and 1986, resulting in yield losses of 30-40%.In another report, grain yield losses of up to 96% were inflicted on susceptible common wheat cultivars (Eshetu, 1985). Epidemics in 1998-1990 have resulted in 58% of yield loss (Badebo and Bayu., 1992). Again in the 2010 main cropping season, severe epidemics of yellow rust were recorded in many parts of wheat growing regions in Ethiopia. Therefore, this paper presents the efforts made to quantify the epidemics and yield losses caused by yellow rust on farmer's fields in Amhara region, northern Ethiopia.

MATERIALS AND METHODS

Experiment locations and layout

Survey was carried out across the major wheat growing zones of Amhara region following the occurrence of yellow rust epidemics in 2010 main cropping season. Wheat and triticale fields were randomly selected and the disease distribution and intensity were evaluated from September 29 to October 10, 2010.Three administrative zones and three districts in each zone were chosen based on the disease occurrence. Debre Elias, Anedid and Goncha Siso Enese districts in east Gojam; Farta, east Este and Lay Gaint in south Gonder and Siya Debirna Wayu, Hagere Mariam and Basona Worana in north Shewa zones were included in the survey. A triplicate of paired treatment trials *i.e* one sprayed with fungicide and the other unsprayed were superimposed on farmer managed wheat and triticale fields in three localities with in each district which made the total plot samples to be 108 in the region. Fungicides Triadimenol (Bayfidan), Propiconazol (Bumper) and Propiconazol (Tilt 250EC) were used as treatments. Bayfidan was sprayed at the rate of 1 litre per hectare, while Bumper and Tilt 250EC were sprayed at the rates of 0.5 litre per kg per hectare each. All the sprays were applied only once. Triadimenol was sprayed on 41 wheat and triticale fields, Bumper on 10 fields, and Tilt 250 EC on three fields.

Data collection and analysis

The survey focused on the widely grown improved bread wheat cultivars HAR 1685 and HAR 604 and a triticale cultivar named Logaw Shibo. In each locality, sprayed and unsprayed matured wheat and triticale crops were randomly selected for evaluation. Disease assessment data were collected along the two diagonals (in an X fashion) of a field at five points using a 0.5 m^2 quadrant (Stubbs et al., 1986). In each quadrant, the number of productive plants was counted and the mean for the five quadrants is used to calculate the number of plants per hectare. Besides, from each quadrant five heads/ spikes were randomly taken with a total of 25 heads collected from sprayed and 25 heads from unsprayed fields. The heads were then threshed and the grains were used to calculate the yield per hectare and determine thousand seed weight.

Data on date and growth stage at which yellow rust appeared first, level of the disease development at spray time, the growth stage at which the crop was sprayed, approximate area of the field were recorded. The yields of infected but sprayed, and infected and unsprayed wheat and triticale cultivars were used to estimate the yield loss as follows: Yield loss = (Mean of sprayed-Mean of unsprayed)/Mean of sprayed*100%.

Losses in thousand seed weight were computed the same way as FAO (1971). Disease incidence and severity were recorded based on (James, 1974).

Grain yield and thousand seed weight differences were analyzed by using the "t" test.

RESULTS

A significant ($P<0.05$) crop loss was inflicted following the 2010 yellow rust epidemic in the Amhara region. Yellow rust resulted in a 34% reduction in grain yield 16.7% reduction in thousand seed weight (16.7 %) in the region.

East Gojam

The mean incidence of the disease was about 100% whereas the severity ranged from 50 – 80% in eat Gojam zone (Table 1). Grain yield assessment was carried out at elevation ranges of 2100 - 2600 m.a.s.l. The improved and major bread wheat cultivar HAR 1685 was grown in Debre Elias and Aneded districts. Yellow rust incidence was first observed in the first 10 days of August in Debre Elias and in the late 20's of September 2010 in Aneded. The crop was at booting growth stage and yellow rust intensity was high (Table 2). Grain yield and thousand grain weight losses were not statistically significant at Debre Elias district while a significant (P<0.05) loss of grain yield was recorded at Anedid district (Table 3). According to this data, the highest and significant losses in grain yield and thousand seed weight were recorded in Goncha Siso Enese district. The losses in grain yield and thousand seed weight were significant for east Gojam zone in general. The losses reached 32% for grain yield and 20% thousand grain weight parameters respectively.

South Gondar

In south Gonder zone, the mean incidence reached 65% and mean severity 45%.The three districts in south Gonder zone were located at altitudes between 2615 and 3450 masl and the dominant crops grown were triticale (cultivar Logaw Shibo) and bread wheat (cultivar HAR 1685). Yellow rust was first observed at the end of August on triticale and late September on bread wheat (Table 2). Triticale was at booting to milky growth stages and bread wheat was at heading stage. The incidence and severity of yellow rust were above 35% on both crops (Table1)

Maximum reductions in grain yield and thousand seed weight were noted in Farta and Lay Gaint districts whereas the minimum and non-significant loss was observed in east Este district. The grain yield reduction for south Gonder zone was 28%. The losses in thousand seed weight ranged from 10-17%. The loss in thousand seed weight was 14.2% for this zone (Table 3).

North Shewa

In north Shewa zone, the distribution was from 35-100% and the severity was in the range of 25 - 70%. The three districts of north Shewa zone were in the altitude ranges of 2500 - 3000 m.a.s.l. Yellow rust infection appeared on the major cultivars HAR 1685 and HAR 604 from the end of August to mid-September (Table 2). The incidence ranged from 55-100% and the severity was 25-70%. During infection the cultivars were at stem elongation to booting growth stages. Reductions in grain yield and thousand seed weight were higher in this zone as compared to the other two zones. Above 50% of the grain yield were lost in Basona Worana followed by 45% loss in Hagre Mariam district. The grain yield loss for north Shewa zone was about 47%. In this zone, the losses in thousand seed weight ranged from 14% to 21%.

Crop and varietal differences

Significant (P<0.05) grain yield losses were recorded for the wheat cultivars HAR 1685 and HAR 604 due to the disease (Fig. 2). The losses ranged from 41.5 - 44% whereas for triticale it was only 24% (Table 4). For both bread wheat cultivars, the losses in thousand seed weight were also significant. However, the loss of thousand seed weight in triticale was not significant.

DISCUSSION

A significant crop loss was inflicted following the 2010 yellow rust epidemic in the Amhara region. The 2010 epidemic was not limited to Amhara region alone. The epidemic was witnessed across the whole wheat growing highland of the country (Denbel, 2014) and in other parts of the world (ICARDA, 2011; Solh et al., 2012; Vergara-Diaz et al., 2015).This survey study evidenced the high occurrence of yellow rust and significant yield loss of 34% in Amhara region.

The use of chemicals had helped in significantly reducing crop loss during the 2010 yellow rust epidemic. The timely and proper use of fungicides gives benefits in the effort to increase crop productivity (Cooper and Dobson, 2007). Hailu and Fininsa (2007) reported a relatively better yield for sprayed plots as compared to unsprayed plots under experimental condition. However, the yield loss in this report might have been under estimated as yield loss was calculated using infected but sprayed and unsprayed plots. Some damage might have already happened to the sprayed plots as well depending on the timing of spray and growth stage of the crop. The spray interval was reported to be a significant factor in the disease severity and rate of epidemic development(Hailu and Fininsa, 2007).

In addition to the yield losses in the current season, seeds harvested from infected fields will obviously affect crop establishment of next generation. Shriveled seeds (Fig 1a-c) are less plump and low in stored food reserve for the next round of crop growth (Boutfirass and Karrou, 2003). There is also effect on the end use of an already diminished yield for processing due to the changes in shape and size of the grain (O'Brien et al., 1990).

The comparison across zones is also not valid as the disease monitoring was not done at similar crop development stages. The booting stage of the crops seems to be more susceptible than the heading and milk development stages. This is in agreement with (Chen, 2005). If a single spray strategy is applied, the stem elongation stage is reported to be appropriate

Table 1. Yellow rust incidence and severity in the major wheat and triticale growing areas of Amhara region, 2010.

Zone	Distract	No. of fields	Yellow rust (%)	
			Incidence	Severity
East Gojam	Debre Elias	2	95	50
	Anedid	2	100	80
	GonchaSisoEnese	5	100	75
South Gonder	Farta	4	50	45
	East Este	3	60	20
	Lay Gaint	3	35	35
North Shewa	SiyaDebirnaWayu	3	55	25
	Hagere Mariam	5	95	70
	BasonaWorana	6	100	60

Table 2. The nine districts surveyed and the type and stage of crop development stage at which fungicides were sprayed in Amhara region, 2010.

Zone	District	Altitude	Cultivar	Rust appeared	Stage	Fungicide
East Gojam	D/Elias	2100-2200	HAR 1685	11/08-26/09/10	BS	Bumper
	Anedid	2200-2450	HAR 1685	15-20/09/10	BS	Bayfidan
	G/S/Enese	2200-2600	HAR 604	2-6/09/10	BS	Bayfidan
South Gonder	Farta	2908-3450	Triticale	21-25/09/10	HS	Bayfidan
			HAR 1685	11/21/09/10	HS	Bayfidan
	East Este	2615-3406	Triticale	22/08-12/09/10	BS	Bayfidan
	Lay Gaint	3036-3220	Triticale	22/08-15/09/10	MS	Bayfidan
			HAR1685	11-25/09/10	HS	
North Shewa	Siya Debirna Wayu	2591-2863	HAR1685	3-16/09/10	SES	Bayfidan
			HAR 604			Tilt 250EC
	Hagere Mariam	2674-2942	HA1685	7-26/08/10	BS	Bayfidan
			HAR 604	15/09/10	BS	Bayfidan
	Basona Worana	2849-3036	HAR604	13-20/09/10	SES	Bayfidan
			HAR1685		BS	Bayfidan

*SES- stem elongation stage, BS – booting stage, HS – heading stage, MS – milky stage

(GRDC, 2005). Developing a vigilant disease monitoring system and applying chemicals timely will be important for better crop productivity.

Yield and grain weight losses were sever on the wheat genotypes HAR 1685 and HAR 604 (Fig. 2, Table 4) as they were relatively old varieties which have already succumbed to yellow rust(Abeyo et al., 2011; Solh et al., 2012). Production of obsolete crop varieties was regarded as one of the major contributors to the 1970's yellow rust epidemic in the north Africa and central and west Asia (Solh et al., 2012). Using resistant cultivars is always the best option for disease management

Table 3. Yield losses of wheat and triticale cultivars due to yellow rust in selected zones and districts in Amhara region, 2010.

District/ Zone/Region	Yield/ha*			1000 seed weight		
	S (kg)	NS (kg)	Loss (%)	S (g)	NS (g)	Loss (%)
Debre Elias	3058.92	2297.53	24.9^ns	35.03	28.87	17.6 ^ns
Anedid	1998.05	1301.27	34.9*	26.6	22.7	14.6 ^ns
Goncha Siso Enese	2252.52	1395.9	38.0*	28.53	20.77	27.2 *
East Gojam	2436.49	1664.9	31.7*	30.06	24.12	19.7 *
Farta	2791.37	1824.43	34.6 *	39.27	32.53	17.1*
East Este	3869.38	3474.97	10.2 ^ns	42.33	38.1	10.0^ns
Lay Gaint	3180.45	1804.15	43.3**	40.97	34.47	15.9^ns
South Gonder	3280.4	2367.85	27.8*	40.86	35.03	14.2*
Siya Debirna Wayu	2358.1	1430.28	39.3**	36.8	31.8	13.6*
Hagere Mariam	2768.2	1518.65	45.1**	33.63	28.23	16.1^ns
Basona Worana	3551.98	1628.53	54.1**	36.13	28.63	20.8*
North Shewa	2892.77	1525.82	47.2**	35.52	29.56	16.8*
Amhara	2869.89	1852.88	35.4**	35.48	29.57	16.7 **

NB. S = sprayed, NS = not sprayed, ns=non-significant, * significant, ** highly significant.

Table 4. Yield losses of wheat and triticale cultivars due to yellow rust in Amhara region, 2010.

Cultivar	Yield/ha			1000 seed weight		
	S (kg)	NS (kg)	Loss (%)	S (g)	NS (g)	Loss (%)
HAR 1685	2564.95	1499.62	41.5 *	32.85	26.53	19.2*
HAR 604	2667.55	1503.67	43.6 *	33.25	26.16	21.7 *
Triticale	3787.04	2885.85	23.8 *	43.31	39.62	8.5^ns

NB. S = sprayed, NS = not sprayed, ns=non-significant, * significant, ** highly significant.

Figure 1. Yellow rust infected and fungicide protected grains of bread wheat (a&b) and triticale (c) cultivars.

(Tadesse et al., 2014). The impact of diseases and other production constraints can be reduced through strong crop improvement programs and effective seed system. Establishing a strong seed system will help in dissemina-

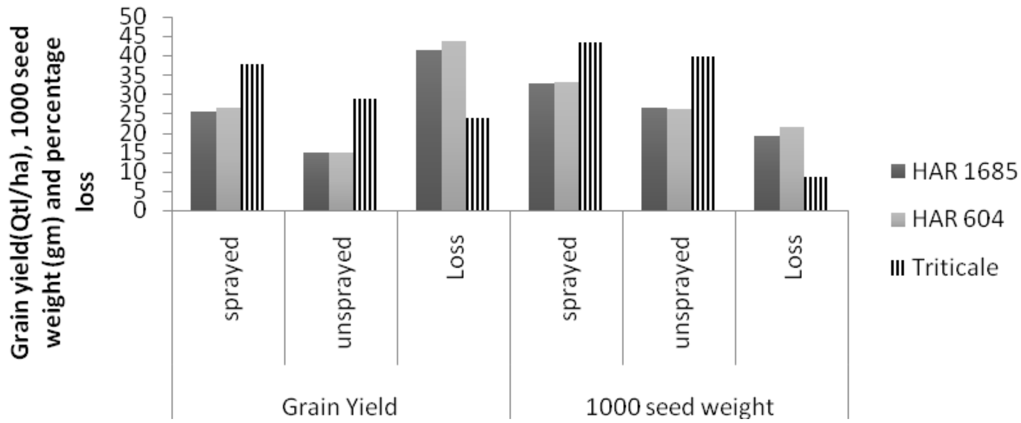

Figure 2. Average performance of the two crops under sprayed and unsprayed conditions and the relative losses in grain yield and thousand seed weight as a result of the 2010 yellow spot epidemic in Amhara region, Ethiopia.

ting the improved seeds to the end users thereby reducing crop loss due to diseases.

ACKNOWLEDGEMENTS

Fungicides were supplied by the office of the Ethiopian Ministry of Agriculture. The Ethiopia Institute of Agriculture, The Amhara Agricultural Research Institute, and The Amhara Regional Bureau of Agriculture are acknowledged for providing technical and financial help.

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