ORIGINAL RESEARCH

Research on Crop Ecophysiology
Vol.13/1, Issue 1 (2018), Pages: 7 - 14

The Effect of the Yellow Rust Caused by *Puccinia striiformis* Westend. *f. sp. tritici* Eriks. (PST) on the Characteristics of the Spike and Yield of Wheat Cultivars

KAVEH, LIMOUCHI*
Ph.D Agronomy. Young Researchers and Elite Club, Dezful Branch, Islamic Azad University, Dezful, Iran.

* Corresponding author email: kavehlimouchi@yahoo.com

Received: 8 Sebtember 2017 Accepted: 18 JANUARY 2018

ABSTRACTS

The present study was carried out in order to investigate the rate of negative effect of wheat yellow rust pathogens on characteristics related to the cluster and yield of wheat cultivars in climatic conditions of north of Khuzestan. The study was carried out using a split plot design in randomized complete blocks with three replications. In this design, the conditions of presence and absence of wheat yellow rust were considered as the main factors, and the most important cultivars planted in the region including Dez and Chamran were considered as the secondary factors. The results of variance analysis indicated that both group of factors had a significant effect on all characteristics except for the cluster length on which yellow rust had no significant effect due to its reliance on genotype. It was also concluded that the interaction effect was only significant on the grain yield at 5% level of. Probability Chamran and Dez cultivars with average of 503.33 and 4808.33 kg/h had the highest and the lowest yield, respectively. Yellow rust disease had a severely negative effect on all characteristics except for the spike length, which finally led to a decrease of 53.92% in the yield compared to appropriate conditions. Given the moisture rate of the weather as the most important factor for the disease spread, it is hoped that the losses caused by yellow rust can be prevented by utilizing suitable managerial methods and most importantly irrigation schedule program and applying appropriate pesticides, which the results indicated that can be justified in regard to economy.

***Keywords*:** Yellow rust, Wheat, Cluster

INTRODUCTION

Yellow rust disease which is caused by fungus *Puccinia striiformis* Westend. *f. sp. tritici* Eriks. (PST) is an important wheat disease in Iran which exists in all regions especially in cold and humid areas and attacks wheat fields and causes a severe reduction in crop particularly when it becomes an epidemic. During 1993-1994, yellow rust epidemic caused a loss of 30% in wheat crop and destroyed about 1.5 million tons wheat (Torabi *et al.,* 1995).

Yellow rust disease is an important wheat disease that is prevalent in cold and temperate weather. Over the last decade, several epidemics of yellow rust have happened in many countries of the world especially in central parts and the west of Asia and the north of Africa. The first observation of yellow rust disease in Iran is reported in 1947 (Esfandiari, 1947). Cummins (1971) considered a comprehensive concept for *p.strriiformis* species and introduced species of 24 types from different Poaceae as the host for this species. Hassebrauk (1965) studied the etymology of this type of fungus causing yellow rust and introduced a Eurasian origin for it and believed that it was first prevalent among uncultivated Poaceae and then infected crop species after they emerged. According to Agrios (2004), temperate weather and a relatively high level of humidity can create grounds for development of wheat yellow rust, and emergence of new species reduces the general resistance among such species. In 1997, Grain and Plant Research, Improvement, and Provision Institute introduced Chamran cultivar which was resistant to yellow rust by 2003, which was attributed to the presence of seedling resistance gene Yr27 in it (Afshari *et al.*, 2003). In evaluating the resistance of 100 advanced lines of dry land wheat to yellow rust in Miyandoab, Pouralibaba *et al*. (2002) reported that 62% of them were fragile at seedling stage while resistant at complete plant stage, 29% were resistant at both stages, 6% were fragile at both stages, and 3% were resistant at seedling stage while fragile at complete plant stage. According to the reports on the resistance of common wheat cultivars to yellow rust in the study carried out by Keshavarz and Torabi (1998), the first infection happened on March 28, 1996 in Dogonbadan region on Azadi cultivar and on May 2, 1996 in Boyer Ahmad area on the same cultivar in the form of 5S. It was also reported that Zagros cultivar was safe, Bayat semi-resistant, Maron, Sefid Sardari and Omid were semi-fragile, and Azadi was fragile. They reported the losses caused by the disease as 4.5% reduction of the crop. In 2002, yellow rust happened in Washington State early due to appropriate weather conditions, and it was not controlled through chemical control, which resulted in a reduction of 20-25% in the crop. In 2003, the resistance of the wheat cultivars decreased in the U.S., and due to emergence of new species of this pathogen, a reduction of 25% in crop was reported (Chen, 2005).

The present study was carried out in order to investigate the rate of negative effect of delayed planting of wheat cultivars in fields afflicted by wheat yellow rust fungal disease in order to come up with a correct evaluation of the rate of losses caused by delayed cultivation of such fields.

MATERIALS AND METHODS

The present experiment was carried out in the crop year of 2010-2011 in the circumstance of Khuzestan Province, Iran with a longitude of 48˚:28′, a latitude of 31˚:50′, and a height above sea level of 33 meters, with loamy soil with pH=7.2. In so doing, the design was carried out in Shavur Field using a split plot design in randomized complete blocks with three replications. The dimension of the plots was 8.5×10 m, the distance between the main plots was 10 m, the distance between the replications was 20 m, and the irrigation and drainage systems were separate. Some of the climatic parameters are presented in Table 1.

The main factor was planting date (first planting: November 8th, delayed planting: December 8th) with seeding rate of 250 kg per hectare. The secondary factors were Dez and Chamran cultivars.

In this experiment, the field was first irrigated, and after the soil moisture reached a favorable level (16-18% based on dry weight) and it was prepared for planting, the early plowing was carried out conventionally using moldboard plow up to a depth of 25-30 cm in all treatments, and the soil was given 11 kg ammonium phosphate per hectare and 50 kg urea nitrogen per hectare according to the results of the soil test. All agronomy practices (except for experiment treatments) like fertilizer and pesticide applications were uniformly carried out for all plots. In regard with previous cultivation, the field was planted with vegetables (*Allium ampeloprasum*) and was fallow for a month before cultivation, so after it was plowed, the remnants from harvesting were buried in and mixed with the soil.

During the growing season, particularly early stages of growth, weed control was carried out using pesticides like Topic with a rate of 1 liter per hectare and Granstar with a rate of 25 g per hectare. In order to prevent the excessive development of the fungus causing yellow rust disease, the Poaceae weeds as the host for the disease around the field were removed. Moreover, Tilt and Folicur pesticides were used especially at the stage when the cluster swells enough depending on the percentage of the disease (to prevent the excessive growth) in order to control the disease.

Parameters such as yield and 1000-grain weigh, grain per spike, deaf grains per panicle, and panicle length were analyzed using SAS Software. Comparison of means was carried out through Duncan test at 5%level of probability.

Table 1. The average air temperature and rainfall during growth

Factor	Nov.-Dec.	Dec.-Jan.	Jan.-Feb.	Feb-Mar.	Mar.-Apr.	Apr.-May	May-June	June-July
Average air temperature	16.9	13.6	13.5	18.4	24.5	31.1	36.6	38
Rainfall	8.4	13.4	85.8	13.7	4.3	9.2	0	0

RESULTS AND DISCUSSION

Grain yield

Based on the results of variance analysis of grain yield, there was a significant difference between different planting dates (1%). There was also a significant difference between the interaction effects of the two factors (5%) (Table 2). According to the mean comparing, it was observed that grain yield decreased by 23.87% as the result of delayed planting (Table 3). Delay in planting increased the pollution rate of the field because the plant faced rainfall early in regard to its growth period, which in turn enhanced the weather moisture (an effective factor in development of the disease) and as a result the disease developed faster and further which caused more damage to the plant. This damage, i.e. spread of wheat yellow rust disease, as statistical measurements have indicated, are 25% more than when the plant is cultivated on time. In other words, thermal stresses caused by delayed planting conditions can be one of the causes for the decrease observed in infected plus (Table 3). In general, the highest yield was related to Chamran cultivar on November 22nd planting with an average of 3733.3 kg per hectare and the lowest yield was related to Dez cultivar with on December 22nd planting with an average of 1633.3 kg per hectare (Table 4). These findings are completely in line with those of the study carried out by Agrios (2004) who concluded that disease pathogen increased as a result of increased humidity and rainfall. They are also in agreement with the results of the study conducted by Pouralibaba *et al.* (2002) who showed that there was an increase in damages caused by wheat yellow rust at early stages compared to what was observed in delayed planting. The results of the present study are also in line with those reported by Afshari *et al* (2003) who referred to higher resistance of Chamran cultivar and with those of the study carried out by Mansouri and Rejaeei (2006) who stated that resistance of resistant cultivars like Chamran will decline with time. Torabi *et al*. (1995) and Chen (2005) respectively referred to decreases of 30% and 25% in yeild of cultivars that are resistant to yellow rust. They also stated that such resistance will disappear over time, which is in line with the results of the present study.

1000 grains weight

This trait was significantly influenced by yellow rust disease, and cultivar at 1% and 5% levels of probability, respectively. However, the interaction effects of the two factors were not statistically different, which indicates that different cultivars were similarly affected by the disease (Table 2). According to the results of mean comparison, yellow rust, caused a reduction of 7 per 1000 grains. However, since weight drop did not lead to an increase in the number of grains in spike and due to the negative correlation between these two, it can be stated that a decrease in the weight of 1000 grains led to a decrease in quality and quantity of the yield. Among the cultivars, Chamran cultivar with an average weight of 28.50 g and Dez with an average weight of 25.16 g had the highest and lowest weights, respectively (Table 3).

These findings are in agreement with those reported by Afshari *et al* (2003) who concluded that this cultivar is less affected by yellow rust disease.

Grain per spike

This trait is one of the most effective characteristics in enhancing the grain yield. Even though its increase causes a reduction in the weight of 1000 grains, it enhances the total yield. The results of variance analysis indicated that this character was significantly different between the two cultivars and yellow rust infection at 1 and 5% probability levels of while the interaction effects of the two factors were not significantly different (Table 2). The results of means comparison indicated a decrease of about 52% in the number of grains per spike as a result of the disease, which can be among the most important reasons for decreased yield of the plant. Dez and Chamran with an average of 20.16 and 16.16 grains per spike had the highest and the lowest number of grains, respectively (Table 3). These results are in line with those reported by Torabi et al (1995) and Chen (2005).

Empty grains per spike

The number of empty grains per spike indicates the real plant's potential to enhance the number of grains and ultimately the total yield. As the observations resulting from variance analysis suggest, there was a significant difference among different levels of yellow rust and the cultivars at 1% level of proability; however, the differences among interaction effects of the two factors were not significant (Table 2). According to the results, there were 2.33 empty grains per spike in favorable conditions free from disease while there were 11 cases in the presence of the disease pathogen. In other words, the plant's potential decreases approximately by 7 grains. Among the cultivars, Dez with an average of 7.83 empty grains and Chamran with 5.50 ones had the most and the fewest number of empty grains in spike, which can be contributed to their lower and higher resistance to wheat yellow rust (Table 3).

Spike length

This traits is one of the characteristics that is related to the genotype of the cultivars and is less affected by environmental conditions. The results of variance analysis also proved this fact. As indicated in Table 3, there was no significant difference between the effects of yellow rust infection levels and the interaction effects of the tow factors in terms of the spike length, while there was a significant

Table2. Analysis of variance for spike characteristics and grain yield of wheat Cultivars

S.O.V	df	Grain yield	1000 grains weight	Grain per spike	Empty grains per spike	Spike length
Replication	2	28158.33^{ns}	2.08^{ns}	2.33^{ns}	4.33^{ns}	0.03^{ns}
stripe rust	1	18575408.33**	161.33**	432.00**	225.33**	0.05^{ns}
Error (a)	2	4658.33	1.58	1.00	2.33	0.04
cultivar	1	5109075.00**	33.33*	48.00*	16.33**	4.32**
stripe rust ×cultivar	1	343408.33*	0.33^{ns}	3.00^{ns}	3.00^{ns}	0.08^{ns}
Error (b)	4	17241.66	2.33	3.500	0.66	0.05
CV(%)		3.16	5.69	10.29	12.24	3.73

Ns, * and **: Nonsignificant and significant at 5 and 1% level of probability, respectively.

Table 3. Mean comparion of panicle and grain yield in wheat Cultivars

Factors		Grain yield (kg)	1000 grains weight	No. grain per spike	No. empty grains for spike	spike length (cm)
Date of planting	Late (Stripe rust)	2911.67 b	23.16 b	12.16 b	11.00 a	6.15 a
	Early (Desirabel)	5400.00 a	30.50 a	24.16 a	2.33 b	6.01 a
Cultivars	Dose	3503.33 b	25.16 b	20.16 a	7.83 a	6.68 a
	Chamran	4808.33 a	28.50 a	16.16 b	5.50 b	5.48 b

Means in each column, followed by at least one similar letter(s) are not significantly different at 5% probability level using Duncan's Multiple Range Test.

Table 4. comparison of grain yield in experimental treatments

	Acting	Grain yield (kg)
stripe rust	Dose	2090.00 d
	Chamran	3733.33 c
Desirability	Dose	4916.67 b
	Chamran	5883.33 a

Means in each column, followed by at least one similar letter(s) are not significantly different at 5% probability level using Duncan's Multiple Range Test.

difference between different levels of cultivars at probability 1% level (See Table 2). According to mean comparisons, it can be observed that yellow rust pathogen had no significant effect on the spike length; however, among the cultivars, Dez and Chamran with respectively average spike length of 6.68 and 5.48 cm, respectively had the longest and shortest lengths, which was attributed to the cultivars' genotype (Table 3).

REFERENCES

Afshari F, Torabi M, Malihipour A. 2003. Occurrence of the new race of wheat yellow rust in Iran. Seed and Plant, 19(4): 543-546.

Agrios GN. 2004. Plant Pathology, 4th edition on Academic Press, pp. 635.

Chen XM. 2005. Epidemiology and control of strip rust (*Puccinia striiformis f.sp. tritici*) on wheat. Can J Plant Pathol, 27: 314-337.

Chen XM, Line RF, Shi ZX, Leung H. 1998. Genetics of wheat resistance to stripe rust. In Proceedings of the 9th International Wheat Genetics Symposium. 2-7 August 1998, University of Saskatchewan, Saskatoon, Sask. Edited by A.E. Slinkard. University Extension Press, University of Saskatchewan, Saskatoon, Sask, 3: 237-239.

Khazar H, Bamdadian A, 1973. The wheat diseases situation in Iran. Proceedings of FAO/Rockefeller Found. Wheat Seminar 4th, pp. 292-299.

Line RF. 2002. Stripe rust of wheat and barley in North America: a retrospective historical review. Ann Rev Phytopathol, 40: 75-118.

Little R, Manners JG. 1992. Somatic recombination in yellow rust of wheat (*Puccinia striiformis*). 2. Germ tube fusions, nuclear number and nuclear size. Trans Brit Mycol Soc, 53: 259-267.

Mansouri B, Rajaee S. 2006. Reaction of some cultivars and promisng lines of wheat to important fungal agents in the Fars provinc. Seed and Plant, 22(4): 455-472.

Nazari K, Torabi M, Hasanpour M, Kashani A, Hooshyar R, Ahmadian MS. 2000. Evaluation of resistance of rainfed cultivars and advanced lines of wheat to yellow rust at seedling and mature plant stage. Seed and Plant 16(2): 252-263.

Niemann E, Scharif G, Bamdadian A. 1968. Die getreide roste in Iran. Wirtsbereich, untercheidung Bedeutung Bekampfung. Entomologie et Phythopathologie Appliquees, 27: 25-41.

Stubbs RW. 1985. Stripe rust. In Cereal rusts. Vol. II. Disease, distribution, epidemiology, and control. Edited by A.P. Roelfs and W.R. Bushnell. Academic Press, New York, pp. 61–101.

Stubbs RW. 1988. Pathogenicity analysis of yellow (*stripe*) rust of wheat and its significance in a global content. 23-28. in N.W. Simmonds and S. Rajram, eds. Breeding strategies for Resistance to the Rusts of wheat. CIMMYT. Mexico, D.F, pp. 300.

Torabi M, Mardokhi V, Nazari K, Afshari F, Forootan AR, Ramai MA, Golzar H, Kashani AS. 1995. Effectiveness of wheat yellow rust resistance genes in different part of Iran. Cereal Rusts and Powdery Mildew Bulletin, 23: 9-12. (In Persian).

Wellings CR, McIntosh RA. 1990. Puccinia striiformis f. sp. tritici in Australasia: pathogenic changes during the first 10 years. Plant Pathology, (Oxford), 39: 316–325.