Pakistan J. Sci. Ind. Res., Vol. 30, No. 4, April 1987

AN EVALUATION OF WHEAT MUTANT LINES FOR RUST RESISTANCE AND OTHER AGRONOMIC TRAITS

S. Anwar Shah, T. Mohammad, S. Hassan and K. Rahman

Nuclear Institute for Food And Agriculture, (N.I.F.A), Tarnab, Peshawar

(Received October 12, 1986; revised February 23, 1987)

Mutation breeding with the objective to improving rust resistance in hexaploid wheat resulted in mutant lines resistant to stripe rust (*Puccinia striiformis*) and leaf rust (*Puccinia recondita*). Dry dormant seeds with 11-12 % moisture of the high yielding but rust susceptible cultivar Lu-26 were mutagenically treated with 250 Gy ^{60}Co gamma radiation and selected between the M_2 and M_4 generations for rust resistance under artificial epiphytotic conditions. Confirmed rust resistant or tolerant M_4-mutant lines were first tested in a M_5-microtrial and 19 promising mutant lines retested in a M_6-trial for heading time, plant height and yield/ha in comparison with the parent cultivar and the rust resistant variety PAK-81. Improved rust resistance exerted in some mutant lines resulted in higher yields than the test cultivars, while heading dates were mostly delayed and four mutants had a significantly reduced plant height. Some of these mutants possess valuable agronomic traits and may either be used directly or as gene donors in crossbreeding for the development of improved wheat cultivars in Pakistan.

Key words: Screening, Wheat mutants, Resistance to rust.

INTRODUCTION

Wheat is attacked by 16 different plant diseases in Pakistan [7] and rusts are the most dangerous and devastating amongst them. Wheat rusts spread very fast and since they keep frequently changing their pathotype spectra (races) a continuous virulence is exerted for attack of the hitherto resistant varieties which endangers a breakdown of their resistance. The rust epidemics of 1977-78 reduced the national wheat production by 10.1 % [6]. Although chemical control of rusts is possible with systemic fungicides, high costs and need for repeated and timely application on large areas is uneconomical and makes it rather impracticable. The development of rust resistant cultivars of wheat by either conventional breeding methods or by induced mutation seems to be the only effective and practical solution of the problem [5].

The induction of resistance to various diseases in different crops by mutagenic agents is a proven and established breeding method [8]. Attempts to induce resistance to stripe rust (*Puccinia striiformis*), leaf rust (*Puccinia recondita*) and stem rust (*Puccinia graminis tritici*) in wheat were reported by Line *et al* [14], Caffey and Wells [1] and Little [13].

Wheat cultivar Lu-26 is cultivated on a large acreage in Pakistan for its good grain quality and high yielding ability. However, the yield performance of this variety is strongly affected by stripe rust in the cooler parts of the country. We have thus attempted to induce resistance to stripe and leaf rust in Lu-26 through gamma irradiation. This paper describes the induction and screening of rust resistant mutant lines under artificial epidemic conditions and reports on thier agronomic evaluation in a M_6-microtrial.

MATERIALS AND METHODS

Wheat cv. Lu-26 (*Triticum aestivum* L.) was used as parent material in this study. Ten thousands dry and uniform seeds with 11-12 % moisture were irradiated with 250 Gy ^{60}Co gamma radiation and the M_1 generation was raised in the field by sowing treated seeds close to each other to discourage excessive tillering. Three main spikes from each M_1 plant were harvested at maturity, threshed separately and planted as spikes to row progenies (pedigree method) in the M_2 generation. The untreated control seeds were planted after every 10 M_2 progenies for easy comparison. All M_2 progenies were artificially inoculated at the five leaf stage with urediospores of *Puccinia striiformis* and *Puccinia recondita* using the sprayer method [11]. The inoculum was obtained from the Cereal Diseases Research Institute (CDRI), Islamabad. CDRI collects urediospores from all over the country to warrant a representative availability with a maximum number of prevailing wheat rust races in the inoculum.

Plants were assayed for rust diseases at dough stage and about 500 plants resistant to stripe and leaf rusts were selected. The selected mutant plants were sown as plant to row progenies in the M_3 generation for the assessment of

their genetic behaviour. Consequent upon reselection about 200 progenies were obtained in the M_3 generation. About 112 genetically stable rust resistant lines were finally selected as a result of continued screening and reselection in the M_4 generation. These true breeding lines were further evaluated in preliminary yield trials in the M_5 generation for agronomic performance. The 19 promising mutant lines were advanced to the M_6 generation and rust resistance as well as other agronomic traits assessed in a micro-yield trial in comparison with the rust susceptible parent variety and the rust resistant commercial cultivar (Pak-81). Each entry in the trial was planted on a plot size measuring 5.4 m^2, having 6 lines 30 cm apart and 3 m long. A randomized complete block design with three replications was applied to enable statistical evaluation. All normal cultural practices (fertilization with N and P, irrigation, hoeing etc.) were adopted. The results were statistically analysed using the Least Significant Difference (LSD) test at 5 and 1 % level of significance [12].

Screening for resistance to stripe and leaf rusts was based on a joint disease assessment for disease severity and response. Severity was recorded as percentage of rust infection according to the modified Cobb's scale [9] while response which refers to different infection types was recorded according to the pictorial scale developed by Stubb and Vecht [10].

Table 1. Mean values of M_6-Mutant lines for different agronomic characteristics
The Parent Cultivar LU-26 and the Rust Resistant Commercial Vareity, Pak-81 are included as Reference

Mutant line/ variety	No. of days to 50 % heading	Plant height (cm)	Yield/ ha(Q)	Reaction to rusts	
				Puccinia-striiformis	*Puccinia recondita*
WM-92-32-2	121.67	67.93	50.00	5 MR	r R
WM-92-39-3	120.67	65.00	51.11	5 MR	5 R
WM-92-34-2	121.0	66.0	51.80	10 R	t R
WM-92-4-2	121.37	67.33	52.22	5 MR	0
WM-2-4-5	116.0	127.80	60.56	5 R	0
WM-89-1	123.67	126.61	68.33	15 MS	20 MS
WM-6-17	125.67	123.93	69.44	20 MR	0
WM-56-1-2	120.0	124.13	65.00	5 MS	0
WM-120-3	118.33	129.53	60.00	15 MS	0
WM-79-7	122.0	118.40	65.56	10 S	40 S
WM-23-1-1	122.67	124.13	63.89	t R	15 S
WM-91-5	120.0	126.63	70.56	5 R	0
WM-91-3	121.67	122.33	61.67	t R	0
WM-92-3	122.0	123.87	60.56	5 MS	0
WM-91-1	120.0	120.87	59.44	5 R	0
WM-97	119.67	112.93	39.78	10 R	0
WM-78	119.33	134.87	52.78	5 R	20 MS
WM-30-6-1	118.0	121.6	70.56	t R	40 S
WM-23-2	111.67	117.07	50.00	t R	0
Lu-26 (Parent)	116.04	119.13	60.26	60 S	t MR
Pak-81 (Check)	128.92	115.73	62.36	5 R	0
CV (%)	3.24	20.67	16.96	–	–
S.E (x)	1.69	1.88	4.17	–	–
L.S.D. $P < .05$	4.82	5.38	11.92	–	–
L.S.D. $P < .01$	6.44	7.20	15.95	–	–

O = No signs of infection, R = Resistant, MR = Moderately resistant, MS = Moderately susceptible, S = Susceptible, t = trace, 5–6 = percent of infection.

RESULTS AND DISCUSSION

Data regarding different agronomic characters of promising M_6-mutant lines and of their parent and the reference commercial cultivar are presented in Table 1. The data reveal that mutation breeding led to considerable improvement of resistance to stripe and leaf rusts as compared to the parent variety. Ten among 19 evaluated mutant lines were found resistant, four moderately resistant, four moderately susceptible and only one line was completely susceptible to stripe rust. Moreover, 11 mutant lines showed no symptoms for leaf rust infection while three mutants exhibited resistant types of infection with a severity score ranging from trace to 5 % and the remaining five mutants were found either moderately susceptible or susceptible to leaf rust. Results indicate that most of the mutant lines rather expressed resistance to leaf rust than to stripe rust. The commercial cultivar (Pak-81), however, exhibited resistance to stripe rust and showed no signs of leaf rust infection.

M_6 mutant lines were also tested for yield and other agronomic traits. The highest yield/ha was observed in the mutant lines WM-30-6-1, WM-91-5, WM-6-17 and WM-89-1, whereas six other mutant lines produced a higher yield than the parent variety. However, the differences in the mean values of these mutants and the control were statistically not significant at 5 % level of significance. Since some of the susceptible to moderately susceptible mutant lines outyielded the parent variety as well as most resistant mutants, these lines appear to be more tolerable to leaf and stripe rusts. Significant variability among rust resistant mutants in plant height indicates that the mutation frequency for this trait is rathter high when induced by gamma rays which confirms the results obtained by other workers [2,3,4]. Moreover, the coincidence of plants with reduced height and rust tolerance/resistance could either be due a disease escape or to genetic reasons (pleiotropy or linkage) and needs further studies as to the causal reasons for this observation. Almost all the mutant lines were later maturing than the parent variety with respect to 50 % heading time. This finding is in agreement with data from Hak and Kamel [5] who reported that late maturity is frequently observed in hexaploid wheat when subjected to high doses of gamma radiation.

The results of this study reveal that mutant lines possess valuable biological and economic qualities like reduced plant height, resistance and/or tolerance to stripe and leaf rusts and a high production potential, and some mutants are agronomically superior to the parent variety (Lu-26) and the standard commercial CV. (Pak-81). Some promising mutants are expected to lead either directly or by cross-breeding to the development of rust resistant and high yielding cultivars of wheat. However, gene-environment interaction over years and locations still have to be investigated to assess parameters of adaptability and genetic stability and to confirm their value for Pakistan.

Acknowledgement. The authors are grateful to CDRI, Islamabad, for costfree provision of the inoculum.

REFERENCES

1. H.R. Caffery and D.G. Wells, Proc.Assoc.Southern.Agr. Workers, **53**, 66, PBA **27**, 1256 (1956).
2. A.S. Chaudhry, , Pakistan J.Agr.Sci., **8**, 82 (1971).
3. A.S. Chaudhry, M.S. Sadiq, and M. Akbar, Japan J. Breed., **26**(3), 197 (1976).
4. A. Gustafsson, Hereditas, **50**, 211 (1963).
5. T.A. Hak and A.H. Kamel (1974). Induced mutation for disease resistance in wheat and field beans, 69-77 in "Induced mutations for disease resistance in crop plants", Proc. Res. Co-ord. meet. at Novi Sad, 4-8 June, 1979, IAEA.
6. F.S Hassan, M. Hussain, and S.A. Rizvi, Wheat disease situation in Pakistan, Proc. Nat. Sem. wheat Res. and Prod. in Pakistan, 6-9 Aug. 1979, Islamabad (1979).
7. F.S. Hassan, Wheat diseases and their control, PARC. Bull. Pl. Pathol. **1**, 3 Pakistan (1980).
8. D.R. Knott, Can. J. Genet. Cyto., **3**, 20 (1961).
9. R.F. Peterson, A.B. Cambell and A.E. Harna, Can. J. Res. **26**, 496 (1984).
10. R.W. Stubb and H. Vecht, Pictorial scale for infection types of *Puccinia striiformis* in Workshop on cereal Dis. Methodol. Sec. 6.3, Alleppo, Syria, 8-18 April, (1979).
11. Anonymous, Inoculation procedures, Sec. 8.4, In "Regional Workshop on Cereal Dis. methodol. Alleppo, Gyria, 8-18 April, 1979.
12. K.A. Gomez and A.A. Gomez., *Statistical Procedures for Agricultural Research* (John Wiley & Sons, Inc., 1984), 2nd ed.
13. R. Little, An attempt to induce resistance to *Septoria nodorum* and *Puccinia graminis* in wheat using gamma rays and EMS as mutagenic agents; Mutation breeding for disease resistance, Proc. Panel Vienna, IAEA: 139-149 (1970).
14. R.F. Line, C.F. Konzak and R.E. Allan, Evaluating resistance to *Puccinia striiformis* in wheat, Induces mutations for disease resistance in crop plants, Proc. Res. Co-ord. Meeting Novisad, IAEA: 125-32 (1974).