Indian J. Genet., 49(3): 297–308 (1989)

EFFECT OF HETEROGENEOUS POPULATIONS ON YIELD AND SPREAD OF STEM RUST IN *TRITICUM DURUM*

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(Received: September 4, 1985; accepted: July 15, 1988)

ABSTRACT

A multiline development programme was started to introduce intravarietal diversity of genes for stem rust resistance in two *durum* varieties, namely NI 146 and HD 4519, through backcrosses using 14 diverse donors. Susceptible components in pure stand showed high rate of rust spread leading to high rust incidence. Multilines showed significantly low rate (67.4% to 84.0%) of rust spread over the mean spreads of their individual components and maintained high degree of population resistance. The susceptibility level of multilines did not increase proportionately with increase in the percentage of susceptible components in the multiline population. The multiline populations showed up to 8.5% increase in yield over the mean yields of their components, considered individually, and gave significantly higher yields (15.5% to 21.0%) over the most susceptible component under heavy disease pressure. Even if 40% of the components of a multiline were susceptible to the most dominant and prevalent races of stem rust, their composite population behaved like a resistant line having no adverse effect on yield. Compared to the recurrent variety, multilines also showed better yield potential over locations.

Key words: *Triticum durum*, intravarietal diversification, multilines, stem rust, adaptability.

Evolution of pure line varieties has generally resulted in good and assured yield advances. This has, however, narrowed the genetic base for disease resistance. Two practical approaches, (a) use of varietal mixtures and (b) production of multiline varieties, have been suggested where one can get the advantage of effective horizontal resistance using the vertical resistance of various components.

Narrow genetic base for rust resistance [1] and high susceptibility, particularly to stem rust, characterise most Indian *durum* genotypes [2]. To introduce intravarietal diversity for resistance to stem rust in *durum* wheat cultivars, a multiline development programme was started at the Indian Agricultural Research Institute, New Delhi, in 1975. Individual component lines representing homogeneous populations and their heterogeneous mechanical mixtures (multilines) were tested to determine the advantages of multilines in terms of yield and spread of stem rust.

MATERIALS AND METHODS

Two *durum* varieties, viz., NI 146 (tall) and HD 4519 (semidwarf), were selected as recurrent parents to develop their component lines through backcrosses involving 14 nonrecurrent donor parents belonging to six different *Triticum* species, namely, *T. timopheevi*, *T. carthlicum*, *T. turgidum*, *T. dicoccum*, *T. durum*, and *T. aestivum*, to provide diverse genic sources of rust resistance. Component lines were developed from 2nd and 3rd backcross generations in NI 146 background and from 1st and 2nd backcross generations in HD 4519 background. Selfing and selection were carried in each backcross generation material till uniform lines were created. These pure line derivatives, the donor varieties, and recurrent parents were subjected to seedling test against selected races (21, 40A and 184) of stem rust to ascertain that the derivatives had common gene(s) for rust resistance with their respective donors [3].

The component lines (homogeneous populations) and their multilines (heterogeneous populations) were evaluated for grain yield and rust spread using the recurrent parents as checks. The experiment was laid out in randomised block design with 4 replications in plots of 10 rows, 3.5 m long, 23 cm apart. A separate trial was laid out for each recurrent parent and its derivatives. In NI 146 background, 20 components and 3 multilines (two with 10 components each and one with 8 components); and in HD 4519 background, 21 components and 2 multilines (one with 10 and the other with 11 components) were assessed. Multilines of two categories were made. Those containing susceptible components were termed "susceptible multilines" (SML), and those comprising resistant components, "resistant multilines" (RML). In NI 146 background, NIML 22 (NIC 103 + 104 + 106 + 109 + 110 + 113 + 115 + 116 + 119 + 120) was resistant and NIML 23 (NIC 102 + 105 + 107 + 108 + 111 + 112 + 114 + 117 + 118 + 121) and NIML 24 (NIC 102 + 105 + 107 + 108 + 111 + 112 + 114 + 121) susceptible multilines. In HD 4519 background, DDML 23 (DDC 302 + 305 + 307 + 308 + 311 + 313 + 315 + 316 + 318 + 320 + 322) was resistant and DDML 24 (DDC 303 + 304 + 306 + 309 + 310 + 312 + 314 + 317 + 319 + 321) susceptible. Components were mixed in equal proportions in each multiline, except NIML 24, where 2 components (NIC 107 and 111) constituted 20% each.

In NI 146 background, NIC 102 and 103 were derived from *T. carthlicum*, NIC 104 and 105 from *T. dicoccum*, NIC 106 and 107 from *T. turgidum*, NIC 118 and 119,and NIC 120 and 121 from two *aestivum* donors, E 8643 and CPAN 1283, respectively; while the remaining 10 components were derived from 5 *durum* donors (2 from each). Similarly in HD 4519 background, DDC 302 and 303 were derived from *T. timopheevi*, DDC 304 and 305 from *T. carthlicum*, DDC 306 and 307 from *T. dicoccum*, DDC 320 from E 8643 (*aestivum*), DDC 321 and 322 from CPAN 1438 (*aestivum*), and the remaining 12 components were derived from 6 *durum* donors (2 from each).

A mixture of susceptible varieties (Sharbati Sonora, Lal Bahadur, Agra Local, Motia, Kathia and Malvi Local) was planted as infector parallel to one replication in each trial, which was inoculated with a mixture of Indian races/biotypes (11, 14, 15, 17, 21, 21A-1, 24, 34, 40, 40A, 42, 42B, 117, 117A, 122, 184 and 295) of stem rust to create epidemic. Observations on the rust spread were recorded after the disease had established in the highly susceptible infectors. Weekly observations were recorded on 9 points (each with 5 tillers) in each plot, arranged along the two diagonals, to study the spread of rust in the experimental material. Rate of rust spread was calculated in terms of "area under disease progress curves" (AUDPC) by the formula:

$$\text{AUDPC} = D\ \{\frac{1}{2}(Y_1 + Y_n) + (Y_2 + Y_3 + \ldots\ldots\ldots\ldots + Y_{n-1})\}$$

where, D—constant time interval between two consecutive rust readings, and Y_1–Y_n—disease scores in 1st to n-th readings.

Rust reaction was recorded on the basis of severity (percentage of infection) and response (pustule type) following Loegering [4]. These observations on disease occurrence were quantified by coefficient of infection (CI), calculated as average rust incidence at the 9 observation points in each plot. The CI was calculated for each week to determine AUDPC. Weekly CI of each treatment was averaged over replications to estimate the weekly increase in rust.

Yield and rust spread of multilines were compared with the average yield and spread of rust of their components and the difference between the two was tested by t test to study synergistic effect. Since rust spread was studied under artificial epiphytotics and the materials developed with NI 146 as well as HD 4519 backgrounds showed similar rust reaction and its spread, these experiments were not repeated. However, the yield performance of multilines was assessed in multilocation tests. In case of NI 146 background, a set of multilines (Table 4) was evaluated against the recurrent variety (NI 146); while in HD 4519 background, they (Table 5) were evaluated against the recurrent variety and the recently released cultivars, DWL 5023, HD 4530, and Raj 1555.

RESULTS

REACTIONS TO RUST AND RUST SPREAD

Among the NI 146 components, NIC 111 showed highest susceptibility and rate of stem rust spread, followed by NIC 107 (Table 1). At seedling stage, NIC 107 was susceptible to races 21 and 40A, while NIC 111 was susceptible to all the three races, 21, 40A and 184, used in the test. Compared to these two susceptible components, all other components and the three multilines, namely, NIML 22, NIML 23 and NIML 24, maintained high degree of resistance and had significantly low rate of rust spread. NIML 22 (RML), containing lines with high degree of resistance to this rust, remained free from infection. NIML 23 and NIML 24, containing 20% and 40% populations, respectively, of the two highly susceptible components, NIC 107 and NIC 111 (50% of each), showed very few plants with maximum 40S intensity, while most plant populations showed high degree of resistance, leading to significant reduction in the spread of stem rust by 80.3% and 84.0%, respectively, in these two susceptible multilines (Table 2) over the average spread of their components.

Table 1. Maximum reaction, coefficient of infection (CI) and area under disease progress curve (AUDPC) of individual lines and multilines to stem rust and their yield (tonnes/ha) in NI 146 and HD 4519 backgrounds

Entry	NI 146 background				Entry	HD 4519 background			
	reaction	CI	AUDPC	yield		reaction	CI	AUDPC	yield
Recurrent variety:					**Recurrent variety:**				
NI 146	5S	1.3	8.5	3.53	HD 4519	30S	7.1	45.0	3.78
Component lines:					**Component lines:**				
NIC 102	15S	2.4	15.0	3.72	DDC 302	20M	6.8	66.0	3.64
NIC 103	5MR	0.5	2.5	3.11	DDC 303	15M	3.3	26.5	3.26
NIC 104	tMR	0.4	2.0	3.47	DDC 304	40S	5.2	22.5	3.68
NIC 105	tR	0.1	0.5	3.55	DDC 305	tR	0.4	1.5	3.28
NIC 106	5MR	0.4	2.0	3.43	DDC 306	60M	7.7	95.0	3.60
NIC 107	80S	48.3	671.0	3.22	DDC 307	15M	1.7	25.0	3.41
NIC 108	tR	0.4	2.0	3.68	DDC 308	5MR	1.3	10.0	3.78
NIC 109	tMR	0.4	2.0	3.68	DDC 309	5M	2.0	17.5	3.78
NIC 110	tMR	0.6	3.0	3.32	DDC 310	90S	41.8	406.0	3.49
NIC 111	100S	80.0	1000.5	3.09	DDC 311	tR	0.2	2.0	4.22
NIC 112	tS	0.4	3.5	3.18	DDC 312	40S	22.7	178.0	3.47
NIC 113	0	0.0	0.0	3.43	DDC 313	5MR	1.0	7.5	3.78
NIC 114	tM	0.4	3.5	3.74	DDC 314	5MR	1.1	8.0	3.76
NIC 115	0	0.0	0.0	3.39	DDC 315	5MR	0.8	4.0	3.99
NIC 116	tR	0.1	1.0	3.76	DDC 316	5M	0.9	8.0	3.57
NIC 117	tR	0.2	1.0	3.60	DDC 317	5M	1.8	14.5	3.51
NIC 118	tR	0.2	1.5	3.72	DDC 318	5M	1.4	5.5	3.91
NIC 119	tR	0.1	0.5	3.95	DDC 319	5M	1.7	15.5	3.99
NIC 120	tS	0.4	2.5	3.47	DDC 320	tR	0.2	1.0	3.55
NIC 121	0	0.0	0.0	3.57	DDC 321	15MS	4.7	30.0	3.68
					DDC 322	20S	9.3	77.5	4.03
Multilines:					**Multilines:**				
NIML 22	(RML) ts	0.2	1.0	3.57	DDML 23 (RML)	5S	0.2	2.0	4.03
NIML 23	(SML) 40 S	2.7	33.5	3.74	DDML 24 (SML)	5MS	2.9	26.5	3.64
NIML 24	(SML) 40 S	4.1	54.0	3.70					
CD			116.1	0.44				38.1	0.40

RML—resistant multiline, SML—susceptible multiline.

Among the HD 4519 components, DDC 310 and 312 showed highest susceptibility, while DDC 302, 304, 306, 321 and 322, in spite of their susceptible reactions, maintained low CI. DDC 310 had the highest AUDPC value for rust spread and differed significantly from all other components and multilines . The CD indicates that DDC 312, 302, 322 and 306 also had significantly higher rust spread compared to the two composites. The remaining components showed high degree of resistance to this rust (Table 1). The resistant multiline (DDML 23), containing resistant components, maintained very high degree of population resistance. Very low value of CI (0.2) for DDML 23 shows that this population had only traces of infection; while CI for 63% of its components, grown as pure lines, ranged between 1.0 and 9.3. In this multiline, rust spread decreased by 89.4% compared to its components, however, the calculated t value was nonsignificant (Table 2). The susceptible multiline DDML 24, containing 20% susceptible components (DDC 310 and 312) gave 2.9

Table 2. Synergistic effect of heterogenous populations on yield and spread of stem rust under epiphytotic condition

Character	Performance of different multilines				
	NIML 22 (100R + 0S)	NIML 23 (80R + 20S)	NIML 24 (60R + 40S)	DDML 23 (100R + 0S)	DDML 24 (80R + 20S)
A. Yield (tonnes/ha):					
Av. of multilines	3.57	3.74	3.70	4.03	3.64
Av. of components	3.50	3.51	3.41	3.74	3.62
Gain over components, (%)	2.0	6.6	8.5	7.8	0.6
Calculated t value	0.427	1.403	1.769	1.957	0.134
B. Spread of stem rust (AUDPC):					
Av. of multilines	1.0	33.5	54.0	2.0	26.5
Av. of components	1.6	169.9	336.8	18.9	81.4
Reduction over components (%)	37.5	80.3	84.0	89.4	67.4
Calculated t value	0.014	3.270**	6.779**	1.241	4.015**

R—resistant population, S—susceptible population.
**Significant at 0.01 level.

CI only. The highest susceptibility of 5 MS, was recorded in DDML 24, while its susceptible components in isolation showed as high infection as 90 S. The rust spread in this multiline drastically dropped by 67.4% compared to the average spread in its components (Table 2).

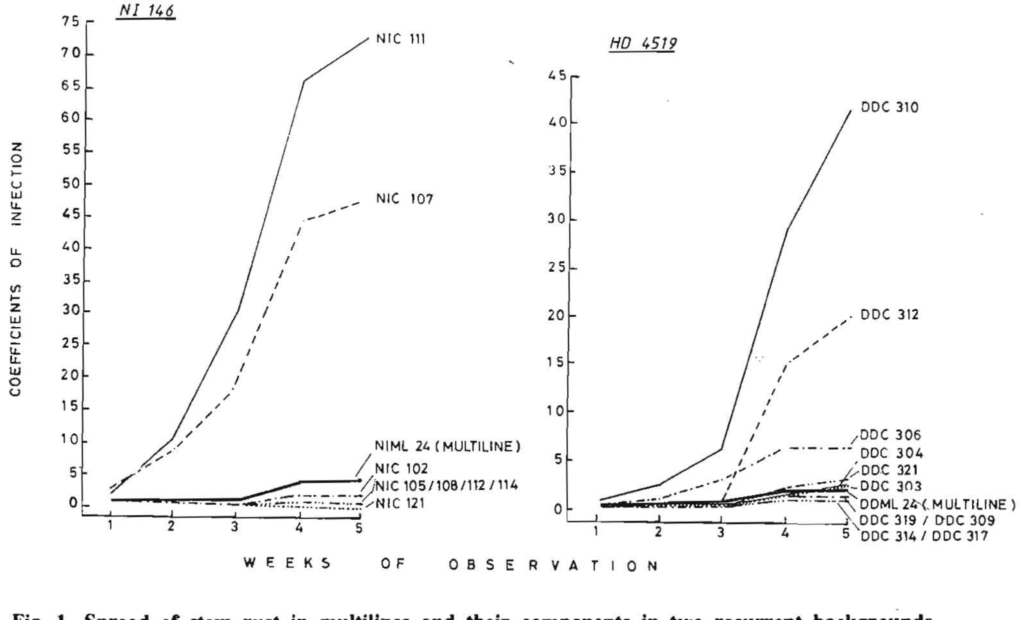

Fig. 1. Spread of stem rust in multilines and their components in two recurrent backgrounds.

In the susceptible pure lines, rust increased very rapidly, giving a steep and more or less S-shaped curve (Fig. 1); but when the same lines were mixed with other lines, the composite population behaved like a resistant line, showing a flat and almost horizontal curve for rust frequency even when 40% of its population was made of highly susceptible components.

YIELD PERFORMANCE

Under artificial epiphytotic, NI 146 multilines yielded significantly higher (15.5% to 21.0%) compared to the most susceptible component but at par with others (Table 1). By and large, these multilines gave 2.0%–8.5% higher yield than the mean yield of their components, which was, however, an insignificant gain (Table 2). A comparison of the data for the recurrent variety (NI 146), susceptible multilines, resistant component (NIC 102), and the most susceptible component (NIC 111) reveals that under artificial epiphytotic, NIC 111 is the lowest yielder and inferior to NIC 102 and the two multilines, NIML 23 and NIML 24, where it constituted 10% and 20% of the populations, respectively. But under low (i.e. natural) infection, NIC 111 was the highest yielder, giving almost similar yield to NIC 102 and the two susceptible multilines (Table 3).

Table 3. Performance of resistant and susceptible components and multilines in NI 146 background under artificial (epiphytotic) rust infection and natural (rust-free) conditions

Strain	Performance under different conditions				
	(yield/(tonnes/ha)		rust reaction		AUDPC
	epiphytotic	rust free	epiphytotic	rust free	(epiphytotic)
NI 146	3.53	2.42	5S	0	8.5
NIC 102 (R)	3.72	2.57	15S	tS	15.0
NIC 111 (S)	3.09	2.84	100S	20S	1000.5
NIML 23	3.74	2.53	tR–40S	0–tS	33.5
NIML 24	3.70	2.61	tMR–40S	0–tS	54.0
CD	0.44	0.37			

Multilocation yield data indicated that the multilines were never inferior to the recurrent parent. In fact, one of the multilines, namely, NIML 1, was constantly better yielder at all the locations compared to the recurrent variety, NI 146 (Table 4).

Both multilines of HD 4519 yielded equal to their components, except DDC 311, which gave higher yield than DDML 24 (Table 1). Multilines DDML 23 and DDML 24 had no significant superiority for grain yield over the mean yield of their components (Table 2). Under multilocation evaluation, where the recurrent variety and the recently released cultivars were included as checks, the yield of multiline DDML 2 was comparable to the new cultivars but significantly superior to the recurrent variety in most of the tests (Table 5). The yield of DDML 6 was also similar to both the checks.

Table 4. Performance of NI 146 multilines over locations

Strain	Yield at different locations over two seasons, tonnes/ha									
	1982-83					1983-84				
	Badnapur	Niphad	Pune	Parbhani	average	Niphad	Badnapur	Akola	Rudrur	average
Multilines:										
NIML 1	3.04	2.29	2.65	3.02	2.75	2.57	3.17	2.21	2.53	2.62
NIML 3	2.55	2.06	2.05	2.76	2.36	2.35	3.40	2.30	2.10	2.54
NIML 5	2.39	2.14	2.20	2.88	2.40	2.25	2.54	2.10	2.49	2.35
NIML 6	2.83	2.29	2.01	2.98	2.53	2.73	2.32	2.25	2.88	2.55
NIML 7	3.53	2.24	2.07	2.95	2.70	2.57	3.34	2.29	2.16	2.59
Recurrent variety:										
NI 146	2.83	2.14	2.10	2.97	2.51	2.30	2.68	2.02	2.24	2.31
CD	0.84	0.42	0.56	1.20		0.38	0.81	0.59	0.57	

A review of the results presented in Table 2 indicates that the heterogeneous populations always recorded improvement in grain yield over the average yield of their components, which was up to 8.5% in NI 146 multilines and 7.8% in HD 4519 multilines.

DISCUSSION

DEVELOPMENT OF RUST

The high values of AUDPC for susceptible components like NIC 111 (1000.5), NIC 107 (671.0) and DDC 310 (406.0) indicate that the degree of stem rust infection and its spread in the susceptible pure stand is very high. But when the same susceptible lines occurred in composite population, they rusted much less. In heterogeneous populations, the number of susceptible plants was also very low. Low

Table 5. Comparison of multilines, recurrent variety, and new cultivars

Entry	Grain yield in different seasons, tonnes/ha				
	1980–81	1981–82	1983–84		average
	Delhi	Delhi	Indore	Delhi	
Multilines:					
DDML 2	5.43	2.65	3.47	6.00	4.39
DDML 6	5.55	2.46	3.15	5.68	4.21
Recurrent variety:					
HD 4519	5.29	2.05	2.87	5.36	3.89
New cultivars (check)	5.38 (DWL 5023)	2.75 (HD 4530)	3.96	6.13 (Raj 1555)	4.55
CD	0.56	0.53	0.51	0.61	

coefficient values of the composite populations indicate that, in spite of the presence of susceptible individuals, the expression of susceptibility in the multilines was much less compared to the proportion of susceptible components in the population.

The very low values of AUDPC for multilines (Table 1) suggest that there was a drastic reduction in the spread of stem rust in the heterogeneous populations. Even in the susceptible multilines like NIML 23, NIML 24 and DDML 24, the rate of stem rust spread decreased significantly by 80.3%, 84.0% and 67.4%, respectively, compared to the rate of disease spread in their components (Table 2). In resistant multilines like NIML 22 and DDML 23, the rate of stem rust spread decreased by 37.5% and 89.4%, respectively, from the average level of disease spread in their components. However, the calculated t values in these cases were nonsignificant as the components were also resistant and showed very poor rust spread even in pure stand.

Growth curves also indicate that in a susceptible homogeneous population (e.g DDC 310 and NIC 111) rust pathogen can multiply at a very high rate, resulting in a severe build-up of rust infection (Fig. 1); while in multilines, even when the components are susceptible, the rust spread is very slow, giving almost a horizontal curve like a resistant line. Several workers [5–10] have reported that the rate of rust spread is substantially reduced in the multilines. Slow rate of rust spread can also be achieved with a resistant cultivar. However, a single cultivar with vertical resistance may suddenly break down with the appearance of a new race or due to heavy incidence of a minor compatible race, leading to substantial yield losses. For example, wheat variety Chhoti Lerma, known for its resistance to stem rust and recommended for cultivation in the Nilgiri Hills to reduce the stem rust inoculum at the foci of infection, broke down with the appearance of a new race 40A [11]. Similarly, the widely adapted variety NI 5439 of Peninsular India, which was resistant to the predominant race 77 of leaf rust, was severely affected with the appearance of biotype 77A [12].

The low frequency of infected plants with a general reduction of rust incidence in the multilines compared to the high incidence in pure stand of the susceptible components suggests that many susceptible plants in the heterogeneous populations simply escape infection, reducing even the initial proportion of infected plants (X0) in the multilines. The low intensity of rust infection on these susceptible plants, as evident from the low values of CI and AUDPC in the multilines, shows that the inoculum multiplication rate (r) has also drastically declined in the composite population. Thus, heterogeneity for rust resistance helps in reducing the initial infection (X0) as well as its multiplication rate (r) due to discriminatory and dilatory actions operating in the multilines, as reported by [5, 6, 8, 13].

It is interesting to note that the susceptibility of heterogeneous populations did not increase proportionately with increase in the proportion of susceptible components in the multilines, as can be seen from the CI and AUDPC values of NIML 22, 23 and 24 (Table 1). For instance, NIML 22 (with 100% R components), NIML 23 (with 20% S + 80% R components), and NIML 24 (with 40% S + 60% R components) showed CI of 0.2, 2.7 and 4.1, respectively. Proportionately, the CI for NIML 24 should have been double of NIML 23 and 40 times of NIML 22.

Similarly the average AUDPC (336.8) for the components of NIML 24 (40% of which is made of the highly susceptible components, NIC 107 and NIC 111) was about twice as much as the average AUDPC (169.9) for the components of NIML 23, in which the proportion of the same S components, NIC 107 and NIC 111, was half of NIML 24, i.e. 20%. However, the AUDPC for NIML 24 (54.0) increased only about 1.5-fold and not 2-fold, over the AUDPC of NIML 23 (33.5). The low CI and AUDPC values for stem rust in NIML 23 and NIML 24 indicated that both the multilines maintained high degree of field resistance even when 40% component in the population (e.g. in NIML 24) was susceptible to the most prevalent and predominant race 21 of stem rust.

Mutliline DDML 24 based on HD 4519 also gave very low value of CI (2.9) and AUDPC (26.5). Browning [14] indicated that a minimum of 40% resistance in field conditions may be adequate for a multiline cultivar of oats against crown rust. Wahl [15] and Brodny [16] independently reported that even 30% frequency of a resistance gene in an indigenous population of wild oats (70% of the population susceptible) in Israel gave adequate protection against the most virulent and prevalent group of strains of the crown rust pathogen.

The extremely slow development of rust in the resistant multilines (RML), as indicated by their very low CI and AUDPC, indicates that the survival of pathogen in the RML populations is almost negligible. Such a host population will exert very high selection pressure on the pathogen, and force the pathogen to mutate and proliferate for its survival. Hence, such resistant multilines are against the multilineal concept of resistance which provides for the survival of the pathogen as well. The larger the discrepancy in disease level between fully virulent and fully avirulent, the keener the provocation for the pathogen to produce a new race and, hence, a high disease pressure tends to increase the rate of erosion of the multiline resistance [17]. The low CI and AUDPC in the susceptible multilines show that in such population, the pathogen is able to survive and propagate itself without causing an epidemic and severe damage to the host population. Similar views have been expressed by others [7, 18]. Frey et al [19] also advocated the "dirty crop" approach. Leonard [20] stressed that a certain level of susceptibility rather than absolute resistance is necessary to stabilise the pathogen population.

The results from both populations in this study were almost identical. This confirms that a population heterogeneous for rust resistance can effectively reduce disease spread in spite of the presence of compatible race population of the pathogen.

YIELD

Synergistic effect (or genotypic complementation) of heterogeneous populations is evident from the fact that the multilines never showed any negative effects in yielding ability over the average yield of their individual components (Table 2). In certain multilines, e.g. DDML 23 and NIML 24, yield advantage of 78% and 8.5%, respectively, was obtained over the mean yield of their components. Increase in the yield of multilines has also been reported in oat [21] and wheat [7, 8, 10, 22, 23].

Among all the component lines evaluated with their respective recurrent parents, NIC 111 showed maximum susceptibility to stem rust (Table 1). Its lowest yield under epiphytotic and highest under low infection indicate that rust reduced its yield drastically (Table 3). Thus, as expected, a susceptible line in pure stand suffers heavily under epiphytotic condition. However, the presence of the same in a composite population does not cause much loss even under epiphytotic situation. NIML 23 containing 20% susceptible components (of which 10% was NIC 111) and NIML 24 with 40% susceptible components (including 20% of NIC 111) showed 6.6% and 8.5% increase in yield, respectively, over the mean yields of their respective components. Thus,even with increasing proportion of the susceptible components in the multilines, the yield gain in the latter increased rather than decreasing. This means that due to low rust infection in the multilines, the yield of susceptible components in the mixed population improved compared to their yield in pure stand to such an extent that even 40% of susceptible components in the composite population did not cause any reduction in the yield of the multiline. Parlevliet [24], Jensen and Kent [25] and Luthra and Rao [8] also reported that the yield of multilines decreases only slightly even under heavy disease pressure with the result that the susceptible plants in a multiline suffer much less even if they constitute as much as 40%-50% of the composite population.

The performance of composite populations in multilocation tests reveals that heterogeneity can add to the yield potential and stability of multilines. Multilines evolved from limited backcross generations can have the advantage of transgressive segregants, and hence, can significantly outyield the recurrent variety having parity in yield with the latest released cultivars. Gill et al. [26] and Malik [10] have demonstrated that multilines evolved from limited backcrosses or multiple crosses have better yield potential compared to the recurrent variety. Since such multilines, in spite of their visual uniformity, contain considerable variability for yield genes from the donors in addition to genes for disease resistance, they are comparable with the "polygenotype" varieties suggested by Zadoks and Groenewegen [27].

Both resistant and susceptible multilines are equally good in their yield performance per se (Tables 1 and 2). However, the susceptible multilines should be preferred to contain the pathogen and stabilize yield.

ACKNOWLEDGEMENT

We thank Dr. M. G. Joshi, Division of Genetics, I.A.R.I., New Delhi, for his critical examination and suggestions for improvement of the manuscript.

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