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EFFECTS OF SELECTION FOR MINOR GENE RESISTANCE TO STRIPE RUST ON YIELD AND OTHER AGRONOMIC TRAITS OF WHEAT

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Two experiments, one each of spring of winter wheat were planted in 1980—81 crop season in a control and an inoculated section with six replications in each at Montana State University, Field Research Laboratory. The spring wheat experiment had three populations derived from three crosses and winter wheat had two populations derived from two crosses. Each population consisted of two generations; F_4 and F_6 in the spring wheat and F_3 and F_5 in the winter wheat, respectively. The F_5 and F_6 were selected earlier for minor gene resistance in F_2 and F_3 generations. The two generations in each population (F_6 Vs. F_4 and F_5 Vs. F_3) were compared, using t-test, for disease resistance, grain yield, plant height, biological yield, harvest index, straw weight, growth rate, tillers number and kernel weight.

Selection for minor genes was effective in two crosses in spring wheat and one cross in winter wheat. Increase in resistance, however, was accompanied with decrease in grain yield. Tiller number, straw weight, biological yield, growth rate and harvest index also suffered decline in two of the three crosses. The crosses which showed no increase in resistance suffered no decline in any trait. It is, therefore, assumed that the decline in grain yield and other traits was associated with the accumulation of minor genes.

INTRODUCTION

Selection of trait may result in an associated increase or decrease in the other traits. Such correlated response can stem from genetic linkage or pleiotropic effect of one gene on the other (Allared, 1960). Presence of awns in wheat was reported to influence the yield and test weight. Selection of awned version of a variety (Onas) out yielded awnless version of the same variety in grain yield and test weight (Suneson *et al.*, 1949).

Similarly slection for stem rust resistance in *Tritcum timophevi* generally resulted in late maturing plant (Allard, 1960). There have been other instaces of this kind reported in the literature. However, effect of selection for resistance genes, especially minor genes, on other traits has hardly been reported. Present investigations were initiated to study the effect of selection for minor genes for stripe rust resistance on grain yield and other agronomic traits of wheat plant.

MATERIALS AND METHODS

The experimental materials consisted of five populations derived from three crosses of the spring wheat and two of the winter wheat. Each cross consisted of two generations (Table-1) obtained by multiplying F_2 and F_4. The spring wheat materials were multiplied twice to obtain F_4 from F_2 and F_6 from F_4 and the winter wheat material multiplied only once to get F_3 from F_2 and F_5 from F_4. The original material was unselected seed but the F_4 consisted of lines selected for minor gene resistance during F_2 and F_3 (Krupinsky, 1977). Subsequent mulliplication i. e. from F_2 to F_4 and F_4 to F_6 in spring wheat and F_2 to F_3 and F_4 to F_5 in winter wheat, however, was a simple increase of the material. The parents involved in the crosses had variable reaction to stripe. The crosses, therefore, showed a range of reaction to stripe rust infection (Table 1).

Table 1. *Number of lines in the two generations of various crosses of spring and winter wheat experiments.*

Crosses	Spring wheat	
	F_4	F_6
Centana/Polk	75	19
Sheridan/Centana	72	17
Shortana/Centana	76	20
	Winter wheat	
	F_3	F_5
Centurk/Itana	98	23
McCall/Itana	98	25

Table 2. *Disease reaction of parents to stripe rust**

Cultivar	C. I. Number	Reaction type**
	Spring Wheat	
Centana	12974	3
Shortana	15233	3
Sheridan	13586	2
Polk	13773	1
	Winter Wheat	
Itana	12933	3
McCall	13842	3
Centruk	15075	2

*Krupinsky (1977)

**Measured on 0-4 scale, 4 being susceptible.

The spring and winter wheat experiments were plated separate during 1980-81 crop season at the Montana State University, Fort Ellis Field Research Laboratory, near Bozeman. Each Experment consisted of a control and an inoculated section, each a replica of the other and planted adjacent. Each section consisted of six replications sown in a randomized block design. The crosses were randomized within blocks and lines within corsses. Each line was sown in a single hill in each replication. The hills were planted in a 30 cm grid using 1.0 g seed in each hill containing approximately 30 seed (Frederickson, 1979). The winter wheat experiment was planted on 27th September, 1980 and the spring wheat on 22, 23 April, 1981.

Control plots were maintained disease free by spray application of the fungicide Bayleton @ 1 kg ha^{-1}. The fungicide was applied weekly starting 24th April and 15th May, 1981 on the winter and spring wheat experiments, respectively. Disease sections were inoculated on 15th May, 1981 with a field collection of stripe rust uredospores mixed with talc in 1 : 50. The winter wheat was inoculated at growth stage-6 (Large, 1954), with the spring wheat plants only three weeks old. The winter wheat experiment had severe infection due to favourable weather early in the season which, however turned hot and dry resulting in low infection in the spring wheat experiment. Readings were taken on severity and infection type using 0-4 and X scale for infection type and 0-100 for severity (Allan *et at.*, 1963).

Data were collected on plant height (cm), heading date, number of tillers per hill, biological yield (grain yield + straw yield), harvest index (seed weight/biological yield, and expressed as percentage), growth rate (biological yield-grain yield/days to heading), grain yield and disease index. Disease index was obtained by multiplying response symbol with severity. Response symbols were obtained by assigning numberical values to infection type as follows : 4=1.0, 3=0.8, 2=0.4, 1=0.2 and 0=0.0. The few mesothetic infection types (X) were assigned a value of 0.6. The data were averaged across replications for all traits and the means were compared using t-test (Snedecor and Cochran, 1967).

The results of the control plots are presented only except for disease indices. Disease index values were taken from inoculated plots to show if selection for minor genes was affective in increasing resistance. Control plot value were used to provide unbiased (from disease) comparison of yield and other traits.

RESULTS AND DISCUSSION

Centana/polk cross

Selection for minor resistant genes increased the resistance in the F_6 as reflected by differences in disease indices of the two generations. The differences were significant inspite of dilution effect of relaxed advancement of generations (Table 3). Attendent with increase in resistance was, however, a decrease in many agronomic traits. Grain yield showed a significant decline from F_4 to F_6. Similar declines were shown by biological yield, growth rate, straw weight and tiller number. Plant height, kernel weight and harvest index showed no effect of accumulation of minor genes.

Sheridan/Centana cross

The cross showed no increase in resistance (Table 3). In fact, the selection resulted in increase in susceptibility and, therefore, in a larger disease index in F_6. Apparently selection was either not effective or only slightly effective which was undone during advancement of generations. Whatever the genetic basis, in the absence of any increase in resistance or tilt toward susceptibility yield and other traits were not adversely affected as observed in the centana/polk cross.

Shortana/Centana cross

Selection for minor gene resistance was effective (Table 3). The F_6

Table 3. *Effect of selection for minor gene resistance to stripe rust on grain yield and other agronomic traits of spring wheat.*

Trait	Centana/Polk			Sheridan/Centana			Shortana/Centana		
	F_4	F_6	(F_4-F_6)	F_4	F_6	(F_4-F_6)	F_4	F_6	(F_4-F_6)
Plant height	111.28	111.33	— 0.05	115.87	117.87	— 1.13	109.80	109.60	0.20
Biological gh dl^{-1} yield	64.26	84.73	9.53**	94.37	96.37	— 2.00	102.59	102.32	0.27
Growth rate g day^{-1}	— 8229	.7101	.1129**	.8066	.8098	—.0032	.8402	.8555	—.0153
Harvest index	32.25	31.75	0.50	34.15	33.91	0.24	36.63	33.83	2.80**
Straw weight g $hill^{-1}$	63.87	57.99	5.88**	62.21	63.69	— 1.48	65.08	67.85	2.75++
Tiller number $hill^{-1}$	39.42	04.63	4.79**	38.00	38.74	— 0.74	42.03	41.92	0.11
100 Kernel weight g	6.87	6.82	0.05	6.83	6.88	— 0.05	6.41	6.10	0.31
Grain yield g $hill^{-1}$	30.39	26.73	3.66**	32.17	32.69	— 0.52	37.51	34.48	3.03**
Disease index	11.72	6.72	5.00**	8.57	11.45	— 2.88**	10.19	6.93	3.26**

++,**,**Significant at .10, .05 and .01 levels, respectively.

generation showed significantly higher resistance than the F_4 generation. The magnitude of difference, however, was not a large as in the contana/polk cross. In line with the magnitude of disease index difference, fewer traits showed decline in F_6. Grain yield and harvest index showed a decrease in F_6 over F_4 significant at 0.01 level and straw weight at 0.10 level. The reduction of harvest index in this cross as against shortana/centana cross in perhaps due to reduction of grain yield alone here as against both the components of harvest in dex in shortana/centana cross.

WINTER WHEAT EXPERIMENT :

Centatk/Itana cross

The F_5 showed significant increase in resistance over F_3 (Table 4). Attendent with increase in resistance was a decline in many traits as observed in the spring wheat crosses showing increase in resistance. All the traits, except kernel weight registered a decrease; significant at 0.01 level in plant height, biological yield, harvest index, straw weight andgrain yield and at 0.05 level in growth rate and tiller number.

McCall/Itana cross

The cross showed no selection response and F_5 generation had large disease index than F_3 thus showing increase in susceptibiliity (Table 4). A tilt towards susceptibility as against resistance had no adverse effect on any trait. The F_5 kernel weight value, in fact, shoved increase over F_3 value. All other traits were comparable in both the generations.

The data in Table 3 and 4 clearly show the effect of selection for minor gene resistance on yield and other traits. Selection, whereever effective resulted in decline in yield and growth traits; biological yield, growth rate and straw weight. Except for kernel weight all other traits showed a decline in one population or the other when resistance increased. In spring wheat experiment, selection was effective in accumulating minor genes in centana/polk and shortana/centana crosses and both these crosses showed a decline in grain yield and other traits (Table 3). The cross sheridan/Centana showed no increase in resistance and had no concurrent decrease in other traits. Similar trend existed in winter wheat experiment. The growth and production traits showed a decline in Centurk/Itana cross where selection accumulated resistance genes. But no decline was observed in McCall/Itana where resistance gene could not be accumulated.

Table 4. *Effect of selection for minor Gene Resistance to stripe rust on grain yield and other agronomic traits of winter wheat.*

Trait	Centurk/Itana			McCall/Itana		
	F_2	F_5	(F_3-F_5)	F_3	F_5	(F_3-F_5)
Plant height cm	119.26	116.64	2.52**	120.90	120.23	0.67
Biological yield g $hill^{-1}$	167.63	144.63	23.00**	158.75	153.79	4.96
Growth Rato g day^{-1}	.7729	.7103	.0626*	.7787	.7796	—.0009
Harvest Index	16.94	13.95	2.99**	15.62	15.95	—.30
Straw weight g $hill^{-1}$	138.39	124.26	14.13**	133.88	128.85	5.03
Tiller Number $hill^{-1}$	56.74	51.28	6.46*	53.16	50.85	2.32
100 Kernel weight g	7.00	6.97	0.03	6.81	7.09	—0.28**
Grain yield g	29.10	20.38	8.72**	24.88	24.93	—0.05
Disease indox	69.17	64.81	4.36**	57.24	62.45	—5.21**

*,**Significant .05 and .01 levels respectively.

It is obvious that both growth and productivity suffered adversly from accumlation of resistant minor genes. Apparently, the resistant genes also influence development of other traits. The precise genetics of this phenomenon cannot be understood from the data, and implication of linkage or pleiotropy of few resistance gene with many yield and productiviey genes does not seem a satisfactory explation. Apparently resistance gene suppersed or retarded some plant process (es) which help plant growth and productivity under stress free conditions as in this experiment. Resistant plants might be representing a complex form which have selective disadvantage as suggested by Van der Plank (1968) in pathogens. The data, however, suggest that selection for minor resistant gene without due regard to agronomic traits lead to plant deterioration and result in low productivity. Any program aimed at increasing resistance should not lose sight of desireable agronomic characteristics.

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