Helminthosporium sativum Resistant Wheat Lines Derived from Wheat (*Triticum Aestivum* L.) and *Thinopyrum Curvifolium*

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ABSTRACT

Spot blotch of wheat, commonly known as helminthosporium, caused by the fungus *Helminthosporium sativum* P.K. and B., is one of the major diseases of wheat in tropical areas. CIMMYT has used different breeding strategies to enhance the resistance of bread wheats to helminthosporium. Two sources were used successfully for the introduction of resistance: i) alien species especially *Thinopyrum curvifolium*, and ii) germplasm from China. Currently, new advanced lines derived from *Triticum aestivum* (2n=6x=42; AABBDD) x *Thinopyrum curvifolium* (2n=4x=28; $E_1E_1E_2E_2$) have been developed by CIMMYT's Wheat Wide Crosses Program which possess improved resistance to helminthosporium. This resistance has not as yet, been associated with categorized alien introgression. The resistant selections have acceptable grain yield, good agronomic types, variable maturity and satisfactory grain finish. Results of the yield trials were conclusive that several *Th. curvifolium* derivatives were superior to both the susceptible (Ciano 79) and resistant (BH1146) checks.

INTRODUCTION

Spot blotch of wheat, commonly known as helminthosporium is now considered to be one of the major diseases of wheat in tropical areas (Saari et al. 1974). It is caused by the fungus *Helminthosporium sativum* P.K. and B. (Syn. *Cochliobolus sativus* Ito et Kurib *Bipolaris sorokiniana* Sacc. ex Sorokin) which can attack all parts of the wheat plant and causes root rot, seedling blight, stem break, spot blotch and black point (Gilchrist, 1985). Under favorable conditions for the disease, yield losses could be between 30 (Mehta, 1985) and 85% (Raemakers, 1988). It was also demonstrated in crop loss assessment experiments that total crop loss could occur if susceptible cultivars were used (Raemakers, 1985). Because of its importance, chemical control measures for helminthosporium are being applied to obtain stability in crop production. Another way to control the disease is through varietal resistance.

CIMMYT have used different breeding strategies to enhance the resistance of bread wheats to spot blotch. Considerable effort was made to identify and incorporate the germplasm with acceptable resistance to this disease. Primarily two sources were used successfully for the introduction of resistance: a) Alien species specially *Thinopyrum curvifolium* (= *Agropyron curvifolium*) and b) germplasm from China.

The objective of the study was to evaluate the yielding ability and other agronomic traits and resistance to *Helminthosporium sativum* of *T. aestivum* (2n=6X=42; AABBDD) x *Th. curvifolium* (2n=4X=28; $E_1E_1E_2E_2$) derived advanced lines of bread wheat, developed at CIMMYT's Wide Crosses Program.

EXPERIMENTAL

Yield and disease evaluations of 23 *Th. curvifolium* advanced derivatives potentially identified as resistant to *Helminthosporium sativum* were done at Poza Rica, Mexico (21° N, 60m elevation) during the 1990-91 and 1991-92 winter cycles (Nov-March). Bread wheat cultivars BH1146 and Ciano 79 were included as resistant and susceptible checks, respectively. Prior to seeding, fertilizer was applied at the rate of 75 kg N/ha (in ammonium sulfate) and 80 kg P/ha (in tri-superphosphate) and supplemented after 30 days of seeding by 50 kg N/ha. For both trials, genotypes were arranged in a randomized complete block design with three replicates. Each plot consisted of eight rows, 20 cm apart and 5 m long, and was seeded at a rate of 100 kg/ha. The trials were surface-irrigated after planting and irrigation was continued as needed until the latest maturing material reached physiological maturity. A full weed, insect, and bird control program was employed during both crop cycles. Days from crop emergence to 50% anthesis were noted for all replicates of each gneotype in both trials. Physiological maturity was recorded when 95% of the spikes in a plot had completely lost their green color.

Plot areas of 3.0 m², which exluded border rows and 0.25 m of border at each end of the plot, were hand-harvested shortly after physiological maturity. The procedures used by Villareal et. al (1992) to obtain grain yield and its components were followed.

All experimental materials were grown unprotected to helminthosporium. Natural helminthosporium epidemic is recurrent in Poza Rica, a location considered as a "hot spot" for this disease. Four criteria were used to evaluate the resistance of the test materials to *Helminthosporium sativum*:

1. **Leaf damage.** Scored during early milk and soft dough stage using the "2-digit" scale, where the first digit corresponds to the height of infection (0-9) 5 = up to mid-plant and 9 = up to flag leaf and the second digit described the desease severity on infected leaves (0-9) 5 = infected foliage is 50% destroyed.
2. **Node damage.** Susceptible lines usually break immediately above the top node or the penultimate node. Stem break caused by node infection is scored at dough stage, using percentage (0% = no stem break).
3. **Spike damage.** The 0-9 scale (5 = 50% of spike destroyed) is used to score the head blight severity of the test entries. Evaluation was done during the milk stage of grain development.
4. **Grain damage** - Black point scoring provides additional information about resistance to *H. sativum*. Seed harvested for each entry were scored for the severity of damage using a 1 to 5 scale (5=81 to 100% of grains have black points).

All variables measured for each genotype were subjected to analysis of variance procedures. A combined analysis of variance was done for the genotypes of the two trials. Mean separation was done using the LSD (Least Significant Difference).

RESULTS AND DISCUSSION

The trials compared grain yield and its components and phenological characters for 23 *Th. curvifolium* derivatives and BH 1146, the resistant check cultivar. Comparison between *Th. curvifolium* derived lines and the susceptible check cultivar Ciano 79 was not included because of the large difference on their yield characteristics.

There were clear genotype differences in yield trial characteristics across the two trials. Data on the 10 best yielding lines are presented (Tables 1 and 2). The mean grain yield of the 23 test entries was 1462 kg/ha as compared to BH1146's yield of 1031 kg/ha across the two trials; a difference that was highly significant ($P<0.01$). Similarly, highly significant difference were found on harvest index (25.2% *Th. curvifolium* derivatives vs 18% BH 1146), grains/m² (7025 vs 5584) and plant height (86.7 vs 90.7 cm) between the *Th. curvifolium* derived genotypes and BH 1146 ($P<0.01$). On other yield components, *Th. curvifolium* derived lines averaged 3.3% more spikes/m² and produced 17.2% more grains/spike as compared to BH 1146 ($P<0.05$). Comparisons indicated that the *Th. curvifolium* derivatives flowered 1.6 days earlier, had 3.2 days shorter grainfilling period but matured 1.6 days later than BH1146 ($P<0.05$). No significant difference on aboveground biomass at maturity, 1000-grain weight and test weight between the test genotypes and BH1146 were found ($P>0.05$).

Based on the helminthosporium damage on leaf, node and grains of all the entries studied, *Th. curvifolium* advanced derivatives generally showed better resistance than both check cultivars. Disease evaluations on the best 10 yielding lines and cultivar checks are presented in Table 3.

The data on the yield tests did demonstrate the yield superiority of several *Th. curvifolium* derived lines as compared to susceptible and resistant checks. It can also be safely concluded that these lines express superior *H. sativum* resistance under the Poza Rica conditions. At present, these selections are

Table 1. Cross and pedigree of the germplasm presented in Tables 2 and 3

Test entry	Germplasm description
1	CS/*Th.curv.*//Glen/3Ald"S"/Pvn"S" CIGM84.295-1M-1PR-4M-OPR-OM-OY-2B-OPR
2	CS/*Th.curv.*//Glen/3/Ald"S"/Pvn"S"/4/ Suzhoe8 CIGM87.120-2PR-2M-2PR-2M-2PR
3	CS/*Th.curv.*//Glen/3/Ald"S"/Pvn"S"/4/ Cno79 CIGM88.795-3B-9PR
4	CS/*Th.curv.*//Glen/3/Ald"S"/Pvn"S" CIGM84.295-1M-1PR-3M-2Y-OM-OY-1PR-4M-3PR
5	CS/*Th.curv.*//Glen/3/Gen/4/Suzhoe#8 CIGM87.524-2Y-3M-3PR-2M-1PR
6	CS/*Th.curv.*//Glen/3/Ald"S"/Pvn"S" CIGM84.295-1M-1PR-4M-OPR-OM-OY-4B-OPR
7	CS/*th.curv.*//Glen/3/Ald"S"/Pvn"S"/4/Ningmay4 /On//Ald"S"/Yangmay4 CIGM87.113-2Y-2M-1PR-1M-1PR
8	CS/*Th.curv.*//Glen/3/Ald"S"/Pvn"S" CIGM84.295-1M-1PR-11M-2Y-OM-OY-2PR-3M-1PR
9	CS/*Th.curv.*//Glen/3/Ald"S"/Pvn"S" CIGM84.295-1M-1PR-4B-OPR-OM-OY-1PR-3M-3PR
10	CS/*Th.curv.*//Glen/3/Ald"S"/Pvn"S" CIGM84.295-1M-1PR-1B-3Y-OM-OY-4PR-3M-3PR

Table 2. Yield trial characteristics of the best 10 yielding advanced lines derived from Thinopyrum curvifolium resistant to Helminthosporium sativum at Poza Rica 1990-91 and 1991-92 replicated yield trials

Plant characteristic	Test entry[a]										BH	Ciano
	1	2	3	4	5	6	7	8	9	10	1146	79
Grain yield (Kg/ha)	1997	1967	1937	1605	1584	1564	1533	1502	1461	1431	1031	116
Aboveground biomass (t/ha)	6.7	6.5	6.3	5.8	5.8	5.8	6.0	5.7	5.3	5.5	5.8	3.3
Harvest index (%)	29.2	29.1	29.6	26.5	26.8	26.9	24.8	26.4	26.9	25.3	18.0	3.7
Grains/m²	8158	9521	7424	6861	8055	6730	7429	7230	7774	6971	5584	1548
Spikes/m²	480.0	471.5	430.0	361.1	441.5	430.7	424.5	447.5	426.7	467.4	414.5	392.6
Grains/spike	16.7	20.0	17.2	19.4	19.0	15.8	17.7	16.0	18.2	15.0	13.5	3.7
1000-grain weight (g)	29.4	26.9	28.2	26.4	26.6	27.4	25.1	26.4	25.3	25.4	26.1	14.6
Test weight (kg/hl)	74.6	72.8	75.0	71.8	72.3	74.9	69.9	73.7	71.5	73.1	70.8	51.7
Plant height (cm)	86.6	78.7	85.7	83.3	85.8	88.3	70.1	87.5	90.8	86.6	90.7	67.7
Flowering days	65.5	70.1	65.5	69.0	65.8	65.8	67.3	66.5	69.5	67.3	68.0	55.0
Physiological maturity(days)	102.0	101.8	106.3	105.5	99.8	105.8	108.5	104.0	110.0	108.3	104.5	103.0
Grainfill period (days)	36.5	31.7	40.8	36.5	34.0	40.0	41.2	37.5	40.5	41.0	36.5	48.0

a) Description of entries in Table 1.

Table 3. Resistance to *Helminthosporium sativum* of the best 10 yielding advanced lines derived from *Th. curvifolium* at Poza Rica 1990-91 crop cycle

	Helminthosporium sativum damage				
Test entry^a)	Leaves*		Node	Spike	Grain
	a	b	(%)	(1-9)	(1-5)
1	92	92	0	2	2
2	92	92	0	4	1
3	92	92	0	2	2
4	92	93	0	2	2
5	94	95	0	2	2
6	92	94	0	3	2
7	94	95	0	4	3
8	93	92	0	3	2
9	93	93	0	2	2
10	93	94	0	2	2
BH1146 (Res.Check)	93	95	100	6	3
Ciano 79 (Sus. Check)	99	99	17	9	5

* Used "2-digit" system of scoring; a = data recorded at early milk stage; and b = data collected during soft dough stage.
a) Description of entries in Table 1.

being incorporated into the mainstream of CIMMYT Wheat Breeding Program and distributed to countries where *H. sativum* is a constraint, such as Nepal, Thailand, Paraguay, etc. Five selections of these materials are currently being registered at Crop Science Society of America to inform wheat scientists of the availability of the germplasm(Mujeeb-Kazi et al.).

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