METHODS USED IN BREEDING FOR RESISTANCE TO SEPTORIA NODORUM IN SWITZERLAND

P.M. Fried

Swiss Federal Research Station for Agronomy Zurich-Reckenholz

In a breeding program it is advantageous to be able to select in each generation for resistance to Septoria nodorum. Because of the erratic occurrence of the disease at our Research Station, we have to inoculate our breeding material every year. Inoculation can occur at different growth stages and with different spore concentrations. We inoculate the F2's to F5's once (500 1/ha spore suspension, 5×10^6 spores/ml) at the booting stage of the early lines, and if disease onset is very low, a second inoculation after heading of the latest varieties is done at a reduced spore concentration (1×10^6 spores/ml). More advanced breeding material of which enough seed is available (usually F_6 to F_{15}) is tested in a special Septoria nursery.

Research of several authors (e.g. Bockmann, Brönnimann, Scott) has shown that yield reduction caused by S. nodorum is highest when inoculation takes place right after heading. From these observations it was concluded that for maximum diffentiation between varieties inoculation should be carried out at that growth stage. In a study to determine the influence of peduncle length on yield reduction, we observed that inoculation after heading can reduce the kernel weight to such an extent that selection on this variable becomes rather difficult (Fried and Brönnimann).

Another factor which interacts significantly with the disease progress is the weather following the inoculation day. If each entry in a nursery is inoculated individually right after heading, the period which is required to do this may last from 2 - 4 weeks under our conditions. A comparison between lines becomes then a comparison between interactions of disease resistance X weather conditions and very often the late varieties are classified as being the most resistant ones.

Measuring the yield reduction by comparing the yield or a yield component between inoculated and non-inoculated plots allows to identify tolerance to the disease. In our current breeding material there appears to be no tolerance present, since high correlations are detectable between the reduction in the grain weight and the areas under the disease progress curves.

If yield measurements are made, then the control plots should be protected chemically. The reason for this is the following: the yield or yield component of a susceptible cultivar is reduced in the control plot, as well. Calculating the quotient inoculated/control makes then appear the susceptible cultivar more resistant than the resistant cultivar.

In addition, cultivars with low kernel weights tend to reduce this component less severely than cultivars with a high kernel weight.

Considering the above factors and taking into account that measuring the yield reduction requires a high amount labour input, we have been adapting our breeding method continuously during the past 3 years. The method we use now for the most advanced breeding lines (beginning in the F6) is the following:

Each entry is planted in a 6 row plot 1.30 m long. The plots are arranged in such a way that they can be inoculated with regular spraying equipment mounted on a tractor. We innoculate the whole nursery a first time when the earliest varieties are at the late boot stage (500 1/ha spore suspension, spore concentration = 5×10^6 spores/ml).

Then, the entries are grouped into 3 or 4 maturity classes according to their heading date. At a given day, when about 1/3 of the entries have headed, each entry in maturity group 1 (early lines) is inoculated individually with a handsprayer, again with 500 1 spore suspension/ha, but at a reduced concentration (1 x 10^6 spores/ml). Inoculation of the entries in the other maturity groups is done accordingly at later dates. We try to have 25 - 30 % of all lines in maturity group 1, 40 - 50 % in maturity group 2 and 25 - 30 % in maturity group 3.

Four to six disease readings (% area with necrosis) are then taken at about 7 - 10 day intervals on the whole plant, the flag leaf, and the heads. Assessments begin when the first symptoms become visible. The areas under the disease progress curves (ADPC) are then calculated and tabulated. Comparisons for selection can now be made but only between entries in the same maturity group. However, this does not completely satisfy, since comparisons between all entries are of interest to the plant breeder. In order to achieve this, I tested different ways of transforming the data; at the moment, the following appears to be the most promising:

For each maturity group, the average of the ADPC for the whole plant, the flag leaf and the heads is calculated. Then, the differences between the means of each group are determined.

Now, one has to determine one group as the reference group (we take the maturity group 2). The values of the other groups are then projected into the reference group by adding (or subtracting) to each value the difference between the means of the reference group to the group to be projected. This then allows to make comparisons between all entries in the nursery. The assumption, however, is made that the distribution for resistance within each maturity group is the same, which might not always be the case. However, for selection in a breeding program of a certain volume, this should not be of great practical consequence.

In our breeding program we like to use a scale from 1 to 9 for as many variables as possible, 1 being very resistant, 9 very susceptible. It is now possible to transform the above mentioned ADPC into values from 1 to 9 by calculating the mean of the group and assigning to the values e.g. $\pm 1/2$ standard deviation (s) around the mean a value of 5, from $\pm 1/2$ s to $\pm 1/2$ s a 4, from $\pm 1/2$ s to $\pm 1/2$ s a 6 and so on. For a quick screening of the data this method can be very useful, but it has the known disadvantages of classifying data into groups.

In the future, we will try to increase the number of replications for each variety and to reduce the number of disease readings to those only where large differences between the entries can be seen. We also test if we could induce a more natural Septoria epidemic by inoculating the nurseries more often but at lower spore concentrations, beginning at an earlier growth stage.

References

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		Whole Plant	Flag Leaf	Heads			
	Early (n = 147)	* ** * ** * ** * ** * ** ** * ** **					
	KLASSE	4 8 12 16 20 24 28 32 36 40 4	8 12 16 20 24 28 32 36 40 44	48 12 16 20 24 28 32 36 40 4			
	Middle (n = 149) Middle (n = 149) = 149)	*	* * * * * * * * * * * * * * * * * * *	*			
	KLASS	E 4 8 12 16 20 24 28 32 36 40	4 8 12 15 20 24 28 32 36 40	4 8 12 16 20 24 28 32			
· · · · · · · · · · · · · · · · · · ·	Late (n = 79)	*	*	*			
			4 0 40 47 00 00 70 77 40	A 0 40 47 70 77			

Fig. 1: Histograms of ADPC WINTER WHEAT 1982 n = 375

KLASSE 4 8 12 16 20 24 28 32 36 4 8 12 16 20 24 28 32 36 40 4 8 12 16 20 24 28 32

CASE-NO		MATURITY CLASS		FLAG	HEADS	WHOLE PLANT	FLAG		WHOLE	FLAG	
	60001	2	53	61	23	53	61	23	6	. 6	5
		2									
		1									
		1									
5	60369	2	38	36	27	38	36	27	4	4	4
5	60433		34	27	26	39	36	25	4	4	4
	60435		42	43	29	42	43	29		5	4
	60460		53	65	54	46	53	35	J	J	J
10	50513		44	57	47	37	45	29	4	5	4
		3									-
15	71919		46	48	27	46	48	27	5		4
. 16	71937		43	44	28	43	44	28	5	5	4
17	71997		53	63	36	53	63	36	6	6	5
18	72075		51	67	21	51	67	21	6	7	3
19	72077		43	52	21	43	52	21	5	5	3
20	72881		32	31	26	32	31	26	3	3	4
21	72988		55	75	40	55	75	40	6		6
22	73045	3	28	20	27	34	29	27	3	3	4
23	73109		53	69	33	53	69	33	6	7	5
24	73128	?	37	30	13	37	30	13	4	3	
25	73303		45	53	46	38	41	28	4	4	4