A SEQUENTIAL SAMPLING PLAN FOR STRIPE RUST MANAGEMENT IN WINTER WHEAT

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SUMMARY

Disease severity:yield loss relationships, severity:incidence relationships and disease distributions were studied in both field plots and commercial fields of Rongotea wheat. Yield responses to fungicide applications were greatest when mean disease severity on the top three leaves was approximately 0.2%. In commercial fields, 0.2% severity was correlated with 10% incidence. Disease distribution did not consistently fit any one mathematical model, but there was evidence of aggregated disease foci with 5-40% incidence. A sampling plan was derived based on these relationships without assuming that a discrete distribution model is fitted. Use of the plan may give more efficient disease control and conservative use of chemicals.

INTRODUCTION

Stripe rust *(Puccinia striiformis)* introduced to New Zealand in 1979, is a major disease of wheat. The majority of wheat cultivars grown commercially are susceptible or highly susceptible to stripe rust (Wright and Sanderson 1982). A current recommendation for stripe rust is to treat seed with triadimenol plus fuberidazole (Baytan F17) and use foliar sprays of triadimefon (Bayleton 25WP) or propiconazole (Tilt 250EC) at first sign of the disease and to spray if reinfection occurs (Harvey and Hedley 1983). However, the recommendation to spray at "first sign" and "reinfection" is subjective and may be interpreted differently by growers. This paper reports studies of factors which are prerequisite for any disease management programme.

A knowledge of disease distribution is required for a sampling technique which reflects disease incidence and severity accurately. Sampling techniques should also be rapid and simple. Incidence sampling requires a low time input and can be carried out accurately with a minimum of training. Besides a sampling technique, a level of disease (action threshold) at which control measure should be taken must be known for management programmes. Action thresholds may be estimated from an understanding of crop sensitivity to disease constraints (Teng and Gaunt 1980) and severity-yield loss relationships (Cook 1980). Incidence sampling and action thresholds may be incorporated into a sequential sampling system for use in the field. Sequential sampling estimates the density of a population in comparison with a specified threshold level and level of confidence using a variable sample size, thereby greatly reducing sampling time (Coggin and Dively 1982).

MATERIALS AND METHODS

Distribution of stripe rust in commercial crops

Four fields of Rongotea wheat were sampled in 1982 and 13 fields in 1983, all located within 10 km of Lincoln College. Each field was monitored by selecting 25 samples along each diagonal of a "W" pattern. Ten consecutive tillers in drill row were selected as the sample unit. Incidence and severity were assessed on the top three fully expanded green leaves of each tiller using standard area diagrams, (Anon. 1972). Sampling ceased in each field after fungicide was applied and resumed approximately 3 weeks later, when chemical control was no longer as effective. Data were analysed for goodness of fit to eight discrete distribution models (Gates and Etheridge 1972 and pers comm).

Severity-yield loss relationships

Rongotea wheat was sown at 150 kg/ha in a Temuka silt loam on the Lincoln College Research Farm on 25 May 1982 and 11 June 1983. Seed was treated with triadimenol plus fuberidazole, 15 g and 2 g, respectively/100 kg of seed. In 1982 16 combinations of applications of triadimefon (125 g/ha) at growth stages 24, 32, 43 and 75 (Zadoks *et al* 1977) were arranged in a randomized block design with three replicates and 15 x 5 m plots. Plots were separated by 3 m of unsprayed Rongotea wheat. In 1983 triadimefon (125 g/ha) was applied, 1, 2 or 3 times based either on scheduled combinations of growth stages 24, 41 and 57 or on action threshold values of 0.1, 0.5 or 1.0% severity (top three fully expanded green leaves). A waiting period of 3 weeks was imposed after a spray before a subsequent spray decision, based on previous experience and the label recommendation for triadimefon. Treatments were arranged in a randomized block design with four replicates of fifteen plots (12 x 12 m) with 6 m of Rongotea wheat between plots. All sprays were applied by tractor rig. Ten plants were selected randomly, weekly in 1983 or biweekly in 1982, from each treatment plot. Stripe rust severity was assessed on all fully expanded green leaves on the main tiller using standard area diagrams (Anon 1972). At harvest, two 3 m strips were harvested mechanically from the central portion of plots and yields adjusted to 14% moisture content.

RESULTS

Disease distribution

No discrete distribution consistently fitted the field survey data from 1982 and 1983 (Table 1). In many cases more than one distribution fitted significantly, especially in the 5-40% incidence range. There was a marked tendency towards aggregated distributions in the 5-40% incidence range (Table 1), indicating the formation of stripe rust foci. A further measure of aggregation in the 5-40% incidence range is a mean to variance ratio with values less than 1.0 indicating aggregation (Southwood 1966). Mean variance values for the 5-40% incidence range showed evidence of aggregation (Table 1). Another measure of distribution is the linear regression of sample mean density and sample mean crowding (Iwao 1968). The intercept reflects how individuals (in this case infected tillers) are distributed within a sample and the slope indicates how individuals are distributed throughout the field. The linear regression for pooled 1982 and 1983 field survey data on the top three leaves accounted for 89% of the variation. The intercept and slope were 0.116 and 1.02, respectively, indicating a loose aggregation of foci (Iwao 1968).

TABLE 1: Summary of distribution analysis of disease on the top three leaves of plants in commercial fields in 1982 and 1983.

	Number of Distributions fitted*		
Distribution model	.01-5%	5-40%**	40%**
Random			
Poisson	5	17	12
Positive binomial	0	18	9
Aggregated			
Negative binomial	0	4	2
Neyman-A	0	3	1
Thomas double Poisson	0	5	2
Poisson binomial	0	5	1
Poisson with zeros	0	7	1
Logarithmic with zeros	0	8	0
None	25	0	0
No. of samples	30	22	12

* More than one distribution may be fitted per sample.
** Incidence on top three leaves.

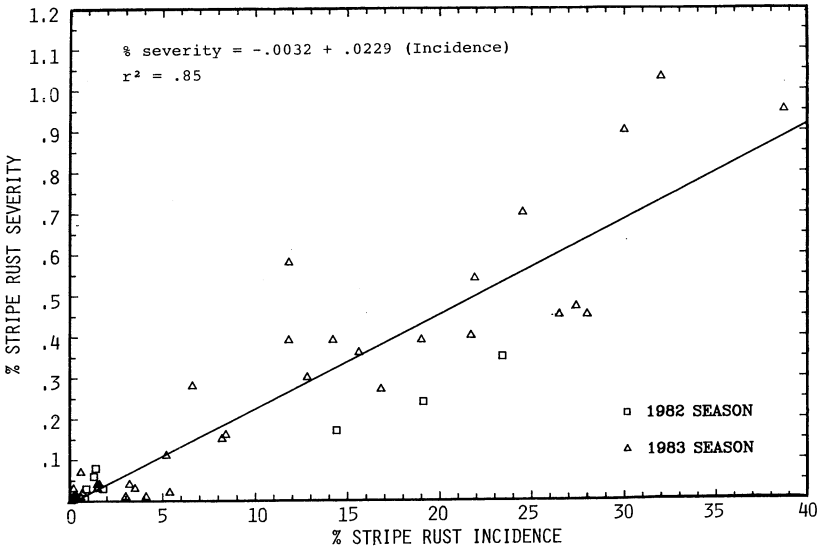

Fig. 1: Relationship between incidence and severity of stripe rust in commercial fields of Rongotea wheat.

Incidence-severity relationships

Incidence on tillers was regressed with disease severity measured on the top three fully expanded leaves at several growth stages in 1982 and 1983. Values above 40% incidence were excluded because the relationship was not as good at greater values (James and Shih 1973) and action thresholds are likely to be less than 40% incidence. Incidence was related to severity as seen in Figure 1. Other regressions based on the top two or on individual leaves were not so significant statistically.

TABLE 2: Percent disease severity on top three leaves and yield of Rongotea wheat (1982).

Number sprays	Days after Sowing 97 G.S. 24	115 31	129 32	142 43	155 59	Header yield (t/ha)
3	0.00*	0.00	0.00*	0.07*	0.60	6.44
2	0.00	0.00	0.40*	0.25*	1.93	6.57
1	0.00	0.00	0.40*	0.32	1.77	6.20
Nil	0.00	0.00	0.40	0.42	19.70	5.57
LSD 5%	-	-	0.31	0.30	2.31	0.44

* Time at which fungicide was applied.

Optimizing fungicide timing

In 1982, 1, 2 and 3 spray programmes which included a spray at G.S. 32 produced the best yields which were significantly greater than the nil treated plots. Disease severity at G.S. 32 was 0.4%. Additional sprays applied at G.S. 24 (severity = 0.00%) or at G.S. 43 (severity = 0.07 – 0.25%) did not increase yield significantly (Table 2).

In the 1983 season a three spray programme based on a 0.1% action threshold produced the greatest yield, an 8% yield increase over the best three spray scheduled programme and a 23% yield increase over nil treatment (Table 3). There was no statistical difference in final yield between two spray programmes based on action thresholds or growth stage schedules.

TABLE 3: Percent disease severity on top three leaves and yield of Rongotea wheat (1983).

Number sprays	Days after sowing / Treatment	105 G.S. 23	112 24	119 24	132 31	146 32	160 41	185 57	Header Yield (t/ha)
3	0.1%	0.18*	0.54	3.74	0.50*	0.84	1.90*	3.65	6.45
3	G.S. schedule	0.18	1.34	3.96*	1.72	5.85	6.44*	7.99*	5.93
2	1%	0.02	0.59	3.94*	3.11	1.65*	0.06	4.08	5.95
2	G.S. schedule	0.18	1.34	3.96*	1.72	5.85	6.44*	7.99	5.80
Nil		0.15	1.63	3.64	13.98	23.52	8.50	18.33	4.98
LSD 5%		0.23	1.41	3.41	6.50	4.82	1.89	1.84	0.42

* Time at which fungicide was applied.

A three spray scheduled programme did not produce a statistically significant yield increase over two spray programmes. Some sprays based on action thresholds were applied later than intended because of concern about spray drift to adjacent plots. In commercial fields the same spray constraints are not encountered and spraying could commence close to the time of the spray decision.

DISCUSSION

Even though the 1982 and 1983 seasons were climatically very different, spray programmes based on initiating sprays when the severity on the top three leaves was between 0.1-0.4% were associated with the best yields in both seasons. Previous experience, trials by McCullough (1982) and MAF recommendations suggest that sprays after anthesis have less effect on final yield than earlier sprays. Evidence presented in this paper suggests that the most effective fungicidal control of stripe rust is a management programme based on spraying when disease on the top three leaves exceeds 0.2% severity. This action threshold may be detected by field sampling for a 10% stripe rust incidence (Figure 1).

The absence of a consistent discrete disease distribution (Table 1) precludes the use of traditional sequential sampling plans (Onsager 1976). To overcome this problem Iwao (1975) developed a sequential sampling system based on the linear relationship between sample mean density and mean crowding. A sequential sampling table was calculated (Table 4) with an action threshold of 10% incidence (1 infected tiller per 10 tiller sample) and a 10% error term.

Thus we recommend that the following steps be taken by growers to implement the management package:

1. Begin sampling at G.S. 15.
2. Walk 20 metres from each border at a corner of the field, sample 10 consecutive tillers along a drill row and count the number of tillers which have stripe rust (pustules) on any of the top three fully expanded green leaves.
3. Walk in a "W" pattern through the field so that 10 samples are evenly spread along each diagonal of the "W" pattern (distance between samples will depend on field size).
4. Keep a running total of the number of infected tiller.
5. After the first 10 (i.e. total of 100 tillers) samples refer to the decision table (Table 4). If the running total is less than the lower action threshold, stop sampling and repeat the following week. If the running total is above the upper threshold, spray as soon as possible and sample again in 3 weeks. If the running total remains between action thresholds, continue up to a maximum of 40 samples. If the total is still between thresholds, sample again 3 days later.
6. Stop sampling at G.S. 61.

TABLE 4: A sequential sampling decision table of the cumulative number of infected tillers (top 3 leaves) based on a 10% incidence action threshold and 10% error.

Sample number	Lower threshold	Upper threshold	Sample number	Lower threshold	Upper threshold
10.	5*	16**	26.	17	35
11.	5	17	27.	18	36
12.	6	18	28.	19	37
13.	7	19	29.	20	38
14.	7	21	30.	20	40
15.	8	22	31.	21	41
16.	9	23	32.	22	42
17.	10	24	33.	23	43
18.	11	25	34.	24	44
19.	11	27	35.	25	45
20.	12	28	36.	25	45
21.	13	29	37.	26	48
22.	14	30	38.	27	49
23.	15	31	39.	28	50
24.	15	33	40.	29	51
25.	16	34			

* If running total is below threshold number, stop sampling and repeat 7 days later.

** If running total is above threshold number, spray as soon as possible.

N.B. If cumulative number of infected tillers falls between lower and upper threshold values, continue sampling up to a maximum of 40 samples (see text).

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