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The effect of pests on the yield and economical value of cereals

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Abstract: One of the most serious factors that limit the yield of cereal crops is fungal diseases. In the Estonian University of Life Sciences field trials with various spray programs of fungicides were conducted to determine the efficacy and economical value of different pesticide combinations. The spray programs with full dose rates of fungicides were not always economically justified nor were the multiple application systems. Yield increase up to 35% in spring wheat and up to 33% in barley was achieved when the timing of pesticide application was optimal and the crop stand was good and had high yield potential. The dominating disease in spring wheat on both trial years was *Septoria* spp. The best control was provided by fungicide Opera (active ingredients pyraclostrobin and epoxiconazole). Barley was infected mostly by *Pyrenophora teres*. The economical efficiency of disease control depended primarily on the weather conditions, crop stand and the quality of cereals. Application of pesticides was economically more effective in spring wheat. Therefore multiple application programs with more expensive pesticides can be recommended. The dense crop stand and an environment favorable for distribution of diseases increased the efficacy of fungicides on barley.

Key words: spray programs, profitability, weather conditions, fungicides

INTRODUCTION

Farmers are interested in obtaining highest yield of the best quality with the lowest possible costs. There are two basic means to increase the economical efficiency of fungicides – by optimization of timing of application and by minimizing the dose rate. The dose rates can be reduced by 25% on wheat in general (Jorgensen & Nielsen, 1994), and in controlling *Septoria* spp., by as much as 50% (Hedge & Verreet, 1999). Wale, 1994; Mercer & Ruddoc (2003) have found that reduced doses can also be used on barley if resistant varieties are grown. The efficiency of chemical crop protection depends on the timing and intensity of infection and time of application, influencing the crop yield and its quality. Crops can best be protected if various fungicides are combined and applied at the moment when diseases have the highest impact to the crop. The first application is usually preventative, before onset of the infection; the following additional sprays are applied when diseases have started to spread and infect the plants. Up to 50 percent of the final yield of a wheat crop depends on the health of the upper leaf, particularly the flag leaf (Lupton, 1972) or, in barley, the top 2 leaves (Anonymus, 2001). The present paper describes the efficacy and economical efficiency of different pesticide combinations on spring wheat and barley in Estonian conditions.

MATERIALS AND METHODS

The field trials with various spray programs of fungicides were conducted at the Estonian University of Life Sciences in 2002–2005.

Trials design were setup with randomized plot layout of 3 replicates; the plot size was 25 m^2 and 500 germinating seeds were sown per square meter. Spring wheat cultivar was 'Triso', known to be susceptible to *Septoria* spp. and the barley cultivar was 'Baronesse', that is moderately resistant to *Pyrenophora teres*. The growth stages of the crop were measured according to BBCH (Stauß et al., 1994). The climatic conditions during the test years are presented in Fig. 1.

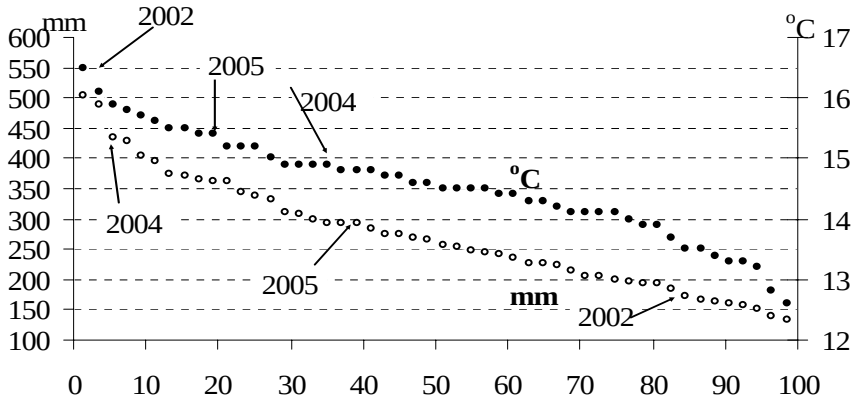

Fig. 1. Precipitation and average temperature in test years and the likelihood of occurrence during vegetation period (May – August) in 50 years.

Diseases were controlled by one or two applications of different fungicides of full and reduced doses (Table 1). Weed control was managed with herbicides Mustang (florasulam; 2,4-D 2-EHE) and Sekator WG (amidosulfuron; iodosulfuron-methyl-sodium) at the crop tilling stage (BBCH 21-22). To reduce the risk for lodging, the spring wheat was sprayed with Cycocel 750 and barley with Terpal (BBCH 31–33). Disease infection was assessed before the first spray, 2 weeks after the application (2 and 3 leaves) and finally (flag leaf) at the stage BBCH 73–75. Previous crops were spring wheat, for barley, and oilseed rape for spring wheat.

Calculation of economical efficiency was based on the pesticide and grain prices given in the price list of Kesko Agro Eesti AS.

RESULTS AND DISCUSSION

It was found that the severity and spread of diseases depended mostly on weather conditions: Tthe higher the precipitation in the growth period (e.g. 2004), the more intensive was the disease infection and the higher the profitability of fungicide application. In the years of frequent rainfalls, the double application of fungicides is economically justified in most cases. Spray programs are more beneficial on spring

wheat rather than on barley. In the dry and warm years (e.g. 2002) the disease infection was low and the fungicide application was economically not justified, preventively or even curatively, especially on barley. Chemical disease control is profitable on spring wheat even in dry years (Table 1). Fungicides with long-lasting efficacy and preventive application are preferable in warm, dry summers. Tango Super contains two active ingredients - epoxiconazole and fenpropimorph - that act synergistically, thus providing long-lasting control in preventive as well as in curative situations. Being a triazole-type product, its price level remains below the strobilurin-type products that are considered to be high-input fungicides. This may explain the greater profitability of Tango Super at low disease pressure conditions in 2002.

The disease severity in cereals and the profitability of fungicides depended also on the distribution of rainfall in the vegetation period and on the crop stand. Fungicides were more effective in dense crop stands where the tilling had been more intensive. In 2005, when precipitation was concentrated in August and the diseases did not significantly affect the yield, the profitability of fungicides was 62% in dense, actively growing barley stands; in a weak wheat stand, the average was only 11%.

Table 1. The profitability % of fungicides and infected leaf area % at different fungicides and application timing.

Fungicide, active ingredient	Dose rate	BBCH*	I,% *	E-yield*	P,%*
SPRING WHEAT 2002					
Untreated			17,5		
Folicur 250 EW (tebuconazole)	0,8	53-55	0	600	-4
Tango Super (epoxiconazole, fenpropimorph)	1,0	53-55	2	740	8
Opera (pyraclostrobin, epoxiconazole)	1,0	53-55	0	760	-16
Tilt EC (propiconazole)	0,5	53-55	6	390	-32
Mentor (fenpropimorph, kresoxim-methyl) + Opera	0,35+0,75	30-31, 53-55	0	730	-29
Allegro Plus (fenpropimorph, epoxiconazole, kresoxim-methyl) + Opera	0,5+ 0,75	30-31, 53-55	0	680	-42
Falcon (tebuconazole, triadimenol, spiroxamine) + Folicur	0,3+0,5	37-40, 59	2	480	-37
SPRING WHEAT 2004					
Untreated			100		
Falcon + Folicur	0,5+0,75	31-32, 37-39	20	1400	45
Mentor + Tango Super	0,4+0,75	31-32, 37-39	10	1760	88
Tango Super + Opera	0,75+0,8	31-32, 37-39	15	2400	103
Opera + Impact (flutriafol)	0,8+0,5	31-32, 37-39	10	2350	98
Untreated			100		
Falcon	0,6	37-39	10	1020	46
Falcon	0,3	37-39	70	480	-16
Falcon	0,15	37-39	100	390	-25
Opera	1,5	37-39	10	2400	96
Opera	0,75	37-39	25	1980	135
Opera	0,37	37-39	70	2110	224

SPRING WHEAT 2005					
Untreated			100		
Tango Super + Opera	0,75+0,75	30-32, 49-50	25	950	-11
Tango Super + Tango Super	0,75+0,75	30-32, 49-50	50	750	-16
Opera	0,75	49-50	25	810	9
Tango Super	1,0	49-50	90	570	-13
Falcon + Sphere	0,6+0,75	30-32, 49-50	25	790	-22
Falcon + Folicur	0,6+0,75	30-32, 49-50	25	770	-14
Sphere (cyproconazole, trifloxystrobin)	0,8	49-50	90	710	2
BARLEY 2002					
Untreated			50		
Folicur 250 EW	0,75	53-55	9	180	-73
Tango Super	0,75	53-55	8	250	-61
Opera	0,75	53-55	5	460	-60
Tilt EC	0,5	53-55	48	10	-99
Corbel (fenpropimorph) + Juventus	0,5+0,75	30-32	5	490	-48
Artea + Amistar	0,4+ 0,75	37-40	5	180	-84
Falcon + Rombus	0,25+0,4	37-40, 59	4	140	-84
BARLEY 2004					
Untreated			100		
Falcon + Folicur	0,4+0,75	31-32, 37-39	50	1410	38
Mentor + Tango Super	0,35+0,75	31-32, 37-39	30	1500	38
Tango Super + Opera	0,7+0,8	31-32, 37-39	20	1560	13
Impact + Opera	0,5+0,8	31-32, 37-39	40	1390	1
BARLEY 2005					
Untreated			100		
Tango Super	1,0	37	30	1660	106
Opera	0,75	37	30	1140	26
Sportak (prochloraz)	1,0	37	50	540	-17
Sphere	0,6	37	30	1570	128
Folicur	0,7	37	30	1200	94
Falcon	0,6	37	60	900	37

E-yield*–extra yield kg ha^{-1}; BBCH*– plant growth stage at fungicide application, I,%*– infected leaf area % at final assessment; P,%*– profitability
(P,%= Profit/charges for crop protection*100)

Due to the late infection the common triazole-fungicides did not control the disease effectively. Strobilurin-type fungicides (e.g. Sphere, Opera) provided strong protection over many weeks; the greening effect provided by strobilurins resulted in yield increase and therefore the single application of strobilurin-type fungicides was profitable in that year. Trifloxystrobin (Sphere - in mixtures with cyproconazole) is absorbed onto leaf surfaces and can be re-distributed to leaves that emerge after spraying, through rain or movement of surface moisture. The movement of trifloxystrobin makes it particularly suited to timings when not all of the target leaves have emerged. Pyraclostrobin (Opera – in mixture with epoxiconazole) moves relatively little. This characteristic, coupled with its strong curative activity against *Septoria* spp., makes it suitable to include with the main flag-leaf spray in wheat.

The range of diseases controlled and differences in the movement characteristics of strobilurins determine decisions on their appropriate use. The efficacy of reduced dose rates depends on the time of infection, applied fungicide, dose rate and application timing. The profitability of disease control can be improved remarkably when the application is made in time. When sprayed as a r preventive measure, the reduced dose rates provide the same level of protection as the full dose at curative application (Opera on spring wheat in 2004). Reduced doses cannot be used against diseases that are not included in the fungicide's spectrum of activity or with pesticides that are known to provide short-term protection. Higher doses are needed for good disease control on disease-susceptible varieties, under high disease pressure.

CONCLUSIONS

The disease infection in the field is enhanced by high precipitation and by optimal plant growth temperature in the vegetation period. In Estonian conditions, chemical disease control is profitable at the high disease infestation level in the field. The recommended dose rates can be reduced and costs for crop protection decreased if the infection level and dominant disease spectrum are determined correctly.

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