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Variety mixtures of winter wheat 1987-1989

Sortsblandinger af vinterhvede 1987-1989

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Summary

During 1987–89, experiments with variety mixtures in winter wheat were carried out at Rønhave and Roskilde experimental stations. Occurrence of mildew, yellow rust, and *Septoria spp.* and yield relations were studied extensively in mixtures with three and four varieties.

Mildew was dominating at Rønhave in 1987 while yellow rust was prevalent in 1988 at Rønhave and at both locations in 1989. *Septoria tritici* was prevalent at Rønhave in 1987.

The use of mixtures in winter wheat reduced the disease level, especially when diseases as mildew and rust were severe. Mixtures did not reduce the level of *Septoria tritici.*

The yield increase by using mixtures without fungicide application was only significant at Rønhave. Differences in the yield between mixtures with three and four varieties were not significant.

Fungicide treatments increased the yield level in mixtures, particularly in mixtures with high disease pressure, but the benefit was better when single varieties with severe disease level were sprayed.

Use of variety mixtures could not replace a single fungicide treatment.

The fungicide effect calculated as average of all treated plots varied from 3.4 up to 8.2 hkg per hectare.

There was no difference in the fungicide effect between application at growth stage 7–8 and 10.1 (Feekes).

Key words: Variety mixtures, winter wheat, mildew, yellow rust, *Septoria tritici.*

Resumé

I perioden 1987–89 blev der ved Rønhave og Roskilde forsøgsstationer, udført sortsblandingsforsøg med vinterhvede. I forsøgene blev der lagt vægt på intensive undersøgelser af sygdomsangreb og udbytteforhold. Der blev anvendt fire vinterhvedesorter: Citadel, Kosack, Kraka og Sleipner i ren bestand og i blandinger med henholdsvis fire og tre sorter i alle mulige kombinationer, i alt ni. I forsøget indgik endvidere en fungicidbehandlet afdeling.

Meldug var den dominerende sygdom ved Rønhave i 1987, hvorimod gulrust var fremherskende

i 1988 og på begge lokaliteter i 1989. Stærke angreb af *Septoria tritici* var fremherskende ved Rønhave i 1987.

Sortsblandingerne reducerede angreb af meldug og gulrust, men derimod ikke *Septoria tritici.*

Merudbyttet ved brug af sortsblandinger uden fungicidsprøjtning var kun signifikant ved Rønhave i 1989 og varierede fra 2,4 til 4,8 hkg/ha. Forskel mellem 3- og 4-sortsblandinger var ikke signifikant.

Fungicidbehandling i enkeltsorter gav stort merudbytte i de rustmodtagelige sorter, Kraka og Sleipner, men relativt mindre merudbytte i de resistente sorter Citadel og Kosack. Merudbyttet ved sprøjtning af blandinger var derimod væsentlig mindre.

Brug af sortsblandinger kan ikke erstatte en enkelt fungicidbehandling.

Fungicideffekten beregnet som gennemsnit af samtlige behandlede forsøgsled varierede fra 3,4–8,2 hkg kerne pr. ha. Der var ingen forskel mellem sprøjtetidspunkter udført ved stadium 7–8 eller 10.1 (Feekes).

Nøgleord: Sortsblandinger, vinterhvede, meldug, gulrust, *Septoria tritici.*

Introduction

The total area grown with winter wheat has increased in recent years in Denmark. One reason is the requirements of the law prescribing an increased percentage of green fields in winter-time. In 1988/89, the area with winter wheat occupied 28% of the total cereal area compared with 21% in 1985/86.

The use of fungicides increases with the area grown with winter wheat as it is common practice to treat wheat two to three times during the growing season. The use of variety mixtures might be of some interest as a method to reduce the use of fungicides. Earlier Danish experiments with variety mixtures of spring barley and winter barley (8,9) showed a reduction in diseases, especially mildew, by up to 50%, thus reducing the need for fungicide application.

The yield increase by using varieties mixtures, especially in spring barley, was 2–5% in these experiments.

Danish local experiments with winter wheat conducted from 1981–84 gave yield increases varying from 0.4 to 3.3% (7).

Similar experiments conducted in Germany and Switzerland with winter wheat showed yield increases from 1.6–4.4% and a reduction in disease severity, especially mildew (3).

Our experiments with four varieties were planned with the specific purpose of assessing diseases in single varieties and in mixtures thereby making it possible to compare the effect of mixtures with three and four varieties together with the effect of from 0–3 fungicide treatments.

Methods

The experiments were placed at Rønhave and Roskilde experimental stations in the years 1987–89 according to the plan showed in Table 1. The design was randomized block-plan with four replicates. The variety Kraka was used as shelter around the blocks.

An assessment of the diseases mildew, rust and *Septoria spp.* was carried out from three to seven times during the growing season. The disease scoring was performed at four to five different places in the plot. The attack of the diseases was recorded as per cent damaged area of the green leaves.

The yield was measured as hkg/ha with 85% dry matter.

The effect of a mixture was defined as the difference between disease severity/yield observed in the mixture compared with average of single varieties.

Five different LSD (95%) values are used in the tables. As an example LSD (variety/mixture) means that one of the single varieties should be compared with the mixture.

Climatic conditions and wintering

The winter months in 1987 had two periods with unusually low temperatures compared with normal conditions.

The average temperature for January was –5.1°C (–0.1°C) and for March –2.0°C (1.8°C) with normal temperatures shown in brackets.

In 1988 and 1989, average temperatures during the winter months were above zero.

Table 1. Varieties, their combinations and resistance against powdery mildew and yellow rust.

Variety	Mildew resistance genes	Yellow rust resistance genes	Other kind of resistance
1. Citadel	Pm 2	Yr 1	
2. Kosack	Pm 4b	–	adult plant resistance
3. Kraka	Pm 5	–	adult plant resistance
4. Sleipner	Pm 2, Pm 6, Pm 8	Yr 9	
5. 1+2+3+4			
6. 1+2+3			
7. 1+3+4			
8. 2+3+4			
9. 1+2+4			

Fungicides

A:	Untreated
B: St. 7–8:	Propiconazol 250 g/l (Tilt 250EC) 0.5 l/ha
C: St. 10.1	Propiconazol 250 g/l (Tilt 250EC) 0.5 l/ha
D: St. 7–8 + st. 10.1:	Propiconazol 125 g/l + fenpropimorph 375 g/l (Tilt Top, 1.0 l/ha)
1988, primo May:	All plots treated against *Cercosporella herpotrichoides* with Prochloraz 450 g/l (Sportak 45EC, 1.0 l/ha)

In all three years, the number of wintering plants was optimum at both locations.

Results

In Table 2, the maximum disease severity in untreated single varieties is shown for the two locations for both years. The diseases mildew and *Septoria tritici* were prevalent at Rønhave in 1987, while yellow rust dominated in both 1988 and 1989.

At Roskilde, *Septoria tritici* dominated in 1987 while yellow rust dominated in 1989. Those years with maximum attack of the three diseases were chosen to investigate the effect of variety mixtures on disease severity.

Table 2. Average severity of diseases at Rønhave and Roskilde from 1987–89. Average of maximum diseases in single varieties in plots without fungicide application.

	% mildew	% *Septoria*	% yellow rust
Rønhave			
1987	16,7 (6/7)	8,0 (6/7)	0 (6/7)
1988	4,2 (11/7)	2,3 (11/7)	12,9 (11/7)
1989	1,1 (26/5)	1,6 (16/5)	23,8 (23/6)
Roskilde			
1987	3,8 (22/6)	15,8 (14/7)	0,8 (14/7)
1988	4,0 (7/7)	3,0 (7/7)	1,3 (7/7)
1989	3,3 (22/6)	5,0 (11/5)	13,6 (22/6)

Mildew

Rønhave

The level of mildew on 7 July was 16.7% as an average of all untreated single varieties (Table 2).

From Fig. 1 it appears that the varieties Citadel and Kraka were severely attacked during the growing season while attacks in Kosack and Sleipner were weaker. In the mixture of the four varieties attacks were weaker than in the first two mentioned varieties but more severe than in Kosack and Sleipner.

Table 3 shows the values and the effect of mixtures observed in plots without fungicide application and the effect of fungicides applied at different times. The disease level in all mixtures was lower than in the most severely attacked single varieties. Among the mixtures with three varieties the disease level varies from 0.3 to 17.3%.

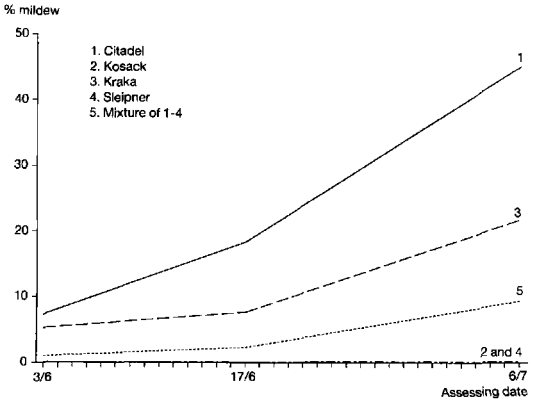

Fig. 1. Mildew in single varieties and mixture of wheat without fungicide application. Rønhave 1987.

Table 3. Per cent mildew and effect of fungicide treatment. Average Rønhave 6/7-1987.

Variety	Without fung. appl.	Effect of mixtures	Fungicide treatment		
			Growth Stages 7-8 (Feekes)	Growth Stage 10.1 (Feekes)	Growth Stages 7-8 + 10.1 (Feekes)
1. Citadel	45.0		20.0	30.0	4.3
2. Kosack	0.1		0.0	0.0	0.0
3. Kraka	21.7		1.7	5.7	0.1
4. Sleipner	0.2		0.1	1.7	0.0
5. 1+2+3+4	9.3	–7.4	0.4	0.1	0.0
6. 1+2+3	17.3	–4.9 n.s.	1.7	5.1	0.0
7. 1+3+4	10.0	–12.9	0.4	5.2	0.1
8. 2+3+4	0.3	–7.0	0.1	0.1	0.0
9. 1+2+4	4.3	–10.8	0.1	0.1	0.0
Av. 1-4	16.7		5.5	9.4	1.1
Av. 6-9	8.0		0.6	2.4	0.1
Av. 1-9	12.0		2.7	5.3	0.5

LSD_1 (variety/mixture): 7.0 LSD_2 (mixture/average of 4-varieties): 5.6 LSD_3 (mixture/average of 3-varieties): 5.7 LSD_4 (treatment/effect of fungicides): 5.8 LSD_5 (treatment/variety or mixture): 8.8

The reduction of disease as an effect of mixture (the observed values in mixtures compared with the estimated mean of varieties in pure stands) was in most cases significant.

The mildew severity was low in 1988 and 1989. The mixtures effect on mildew was only significant in one incidence on 9 June 1988.

Fungicide treatment

In the fungicide sprayed plots (Table 3), the mildew level was reduced – most in varieties and mixtures where the disease level was severe.

The difference between fungicide application at stage 10.1 and stage 7–8 was not significant. The fungicide effect (reduction) was significant for all treatments. In 1988 and 1989, the same trends in results were seen.

Roskilde

The maximum mildew level, estimated as an average of all untreated single varieties, was low, varying from 3,3 to 4,0%. The variety Citadel was the most susceptible in all three years.

The effect of mixture was significant in both 1987 and 1988 except for two cases. In 1989, the effect was not significant.

As an example, Fig. 2 shows a comparison of values observed in the mixture with four varieties and the estimated average of the four single varieties and of all the three component mixtures.

The severity of mildew in the mixture with four varieties was significantly lower than both the average of four varieties and the average of all the three component mixtures. The same results were obtained in 1988, but not in 1989.

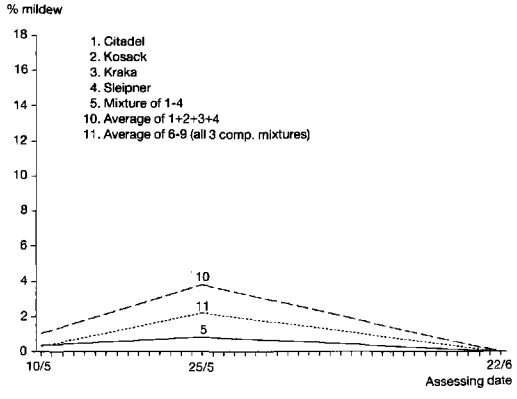

Fig. 2. Mildew. Mixture of four varieties compared with average of observed values. Roskilde 1987.

Table 4. Per cent *Septoria spp.* and effect of fungicide treatment. Average Rønhave 6/7-1987.

Variety	Without fung. appl.	Effect of mixtures	Fungicide treatment		
			Growth Stages 7-8 (Feekes)	Growth Stage 10.1 (Feekes)	Growth Stages 7-8 + 10.1 (Feekes)
1. Citadel	16.7		5.0	10.0	0.4
2. Kosack	1.7		6.7	3.7	0.1
3. Kraka	3.7		0.1	3.3	0.1
4. Sleipner	10.0		0.2	5.0	0.2
5. 1+2+3+4	8.3	+0.3 n.s.	0.3	0.2	0.1
6. 1+2+3	8.3	+1.0 n.s.	0.3	5.0	0.2
7. 1+3+4	10.0	–0.1 n.s.	0.4	2.3	0.1
8. 2+3+4	4.3	–0.8 n.s.	2.0	1.7	0.1
9. 1+2+4	6.7	–2.7	0.5	5.0	0.2
Av. 1-4	8.0		3.0	5.5	0.2
Av. 6-9	7.3		0.8	3.5	0.2
Av. 1-9	7.7		1.7	4.0	0.2

LSD_1 (variety/mixture): 2.5 LSD_2 (mixture/average of 4-varieties): 2.0 LSD_3 (mixture/average of 3-varieties): 2.0 LSD_4 (treatment/effect of fungicides): 2.0 LSD_5 (treatment/variety or mixture): 3.1

Fungicide treatment

The highest mildew disease severity was in 1988 on 7 July. The fungicide effect was significant but not the difference between fungicide application time. On 7 June 1989, with the highest occurrence of mildew, the fungicide effect was not significant.

Septoria spp.

Rønhave 1987

The average disease level on 6 July, mainly *Septoria tritici,* was relatively high with 8.0% attack, but, as shown in Table 4, varying in the single varieties. The varieties Citadel and Sleipner were most severely attacked with respectively 16.7% and 10%. There was no significant reduction in the *Septoria* severity in most of the mixtures compared with the average level of disease in pure stand.

The difference between values in three and four component mixtures were not significant.

The disease level in 1988 and 1989 was low and the effect of mixture was not significant in most of the mixtures.

Roskilde

1987

This year the disease level was rather high with the most severe attacks in the varieties Citadel and Kraka (Table 2).

The effect of mixture was nonsignificant.

1988

The varieties Citadel and Sleipner had respectively 5% and 2.3% attack with lower disease level in Kosack and Kraka. The effect of mixture was nonsignificant. Also in 1989, the differences were nonsignificant.

The effect of fungicide treatment

Rønhave

In 1987, the effect of fungicide treatment was significantly different from untreated and the best effect was obtained with two sprayings at stage 7–8 and stage 10.1 on 6 July (Table 4).

In 1988 and 1989, the difference was not significant.

Table 5. Per cent yellow rust and effect of fungicide treatment. Average Rønhave 23/6-1989.

Variety	Without fung. appl.	Effect of mixtures	Fungicide treatment		
			Growth Stages 7-8 (Feekes)	Growth Stage 10.1 (Feekes)	Growth Stages 7-8 + 10.1 (Feekes)
1. Citadel	0.0		0.0	0.0	0.0
2. Kosack	0.2		0.2	0.0	0.0
3. Kraka	20.0		7.0	0.5	0.0
4. Sleipner	75.0		0.8	0.0	0.0
5. 1+2+3+4	6.7	-17.1	0.0	0.0	0.0
6. 1+2+3	6.7	0.0 n.s.	0.7	0.1	0.0
7. 1+3+4	8.3	-23.4	0.8	0.1	0.0
8. 2+3+4	6.7	-25.0	2.3	0.2	0.0
9. 1+2+4	0.7	-24.4	0.1	0.0	0.0
Av. 1-4	23.8		2.0	0.1	0.0
Av. 6-9	5.6	1.1	1.0	0.1	0.0
Av. 1-9	13.8		1.4	0.1	0.0

LSD_1 (variety/mixture): 3.0 LSD_2 (mixture/average of 4-varieties): 2.4 LSD_3 (mixture/average of 3-varieties): 2.5 LSD_4 (treatment/effect of fungicides): 1.7 LSD_5 (treatment/variety or mixture): 3.2

Roskilde

Only in 1987, the fungicide effect was significant but not in 1988 and 1989 where the disease level was low.

Yellow rust

Rønhave

No attack was observed in 1987. In 1988, yellow rust was only observed in one variety, Kraka, with 52% rust on 11 July.

In 1989 the level of yellow rust was lower in all mixtures compared with the level in Kraka and Sleipner. It should be noted that the disease level in the mixture with Citadel + Kosack + Sleipner was very low, though Sleipner had 75% in pure stand (Table 5).

In the mixture with four varieties the rust severity was 6.7% which is equivalent to a reduction of the attack of about 72%.

In the three component mixtures the effect was also very high except for one mixture, where it was zero.

From Fig. 3 it appears that the values for the mixture with four varieties and the average of the mixtures with three varieties were almost similar but significantly different from the average of the four varieties.

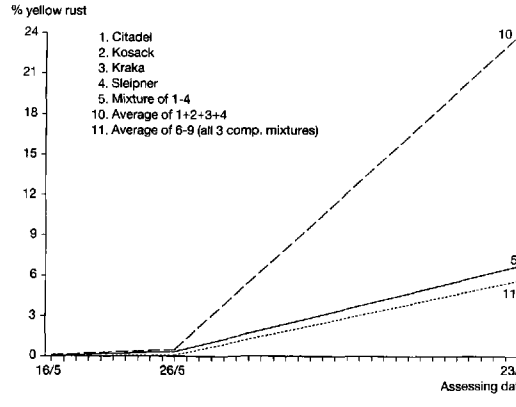

Fig. 3. Yellow rust. Mixture of four varieties compared with average of the observed values. Rønhave 1989.

Table 6. Average effect of mixtures and yield level hkg/ha (average of four varieties in pure stand) during three years in plots without fungicide application.

No.	Mixtures	Rønhave			Roskilde		
		1987	1988	1989	1987	1988	1989
5	1+2+3+4	–5.1	0.1	3.1	–5.8	0.9	0.9 n.s.
6	1+2+3	–2.7	–2.1	2.4 n.s.	–3.3	–3.9	2.9
7	1+3+4	–9.1	–0.7	4.8	–6.9	–1.1	–1.3 n.s.
8	2+3+4	–2.0	0.6	3.5	3.8	2.1	–3.6
9	1+2+4	–5.4	0.3	2.4 n.s.	2.1	–1.1	–2.9
Average yield level of varieties in pure stand		64.7	75.9	71.2	39.9	69.6	68.1

Roskilde
Both in 1987 and 1988, Kraka was the only variety infected with yellow rust but at a low level, 3–5% attack. The mixture did not show any significant effect on the disease level. In 1989, the attack in Kraka was severe, about 50%, and in Kosack and Sleipner it was weak. The effect of mixture was significant in all mixtures where Kraka was one of the varieties.

The effect of fungicide treatment
Rønhave
In 1988, all sprayings reduced the high attack in Kraka to a low level at all application dates.

In 1989 (Table 5) the fungicide effect was significant for all treatments. Although Sleipner had 75% disease severity in the untreated plots, one application was able to give a significant reduction of disease to under 1%.

Roskilde
Only in 1989, the fungicide effect was significant. Kraka had the highest disease severity with 50%; however two applications reduced the disease level to under 1%.

Yield

The analysis of variance showed in 1987 and 1988 that the yield for effect of mixtures and effect of fungicide treatment compared with untreated were both nonsignificant.

In both years, the yield increases showed positive or negative values at random.

In 1989, the yield increases were significant in three of the mixtures at Rønhave but only in one mixture at Roskilde (Table 6).

Rønhave
1989
Among single varieties, the yield varied much, Citadel giving highest yield, 81.4 hkg, and Kraka lowest, 60.5 hkg (Table 7).

The effect of mixture of the four varieties was 3.1 hkg (significant). The average of all mixtures was significantly higher than the average of the varieties in pure stand. The yield of the four components mixture was not significantly higher than the average of the three comp. mixtures (6-9).

The effect of fungicide sprayings
The varieties responded very differently to fungicide applications. For instance one spraying in Sleipner gave 22-25 hkg yield increases as compared to –0.3-1.6 hkg in Kosack.

Spraying of the mixtures gave yield increases significantly different from untreated, but much lower than the yield increase in Kraka and Sleipner.

The fungicide effect was about 8-10 hkg with no significant difference between time of spraying or two sprayings.

Roskilde
At this location the yield relations were quite different from those at Rønhave. Sleipner yielded about 80 hkg and Citadel about 75 hkg.

The yield increase in the mixtures compared with the average of the four varieties was not significant and was often lower. The difference between three and four component mixtures was not significant.

One single spraying in Kraka gave yield increases of about 8-10 hkg, but not in the three

Table 7. Yield relations hkg/ha. Rønhave 1989.

Variety	Without fung. appl.	Effect of mixtures	Fungicide treatment		
			Growth Stages 7-8 (Feekes)	Growth Stage 10.1 (Feekes)	Growth Stages 7-8 + 10.1 (Feekes)
1. Citadel	81.4		86.1	84.5	84.1
2. Kosack	74.3		75.9	74.0	75.5
3. Kraka	60.5		74.1	71.0	74.2
4. Sleipner	68.4		90.8	93.0	94.2
5. 1+2+3+4	74.3	3.1	80.6	82.4	82.5
6. 1+2+3	74.5	2.4 n.s.	79.7	79.5	81.6
7. 1+3+4	74.9	4.8	81.8	82.9	86.9
8. 2+3+4	71.2	3.5	79.1	79.0	81.5
9. 1+2+4	77.1	2.4 n.s.	81.8	83.9	82.9
Av. 1-4	71.2		81.7	80.6	82.0
Av. 6-9	74.4		80.6	81.3	83.2
Av. 1-9	72.9		81.1	81.1	82.6

LSD_1 (variety/mixture): 3.5 LSD_2 (mixture/average of 4-varieties): 2.8 LSD_3 (mixture/average of 3-varieties): 2.8 LSD_4 (treatment/effect of fungicides): 3.5 LSD_5 (treatment/variety or mixture): 4.8

other varieties where the yield increase varied from 0.8 to 3.4 hkg. Two sprayings in Kraka and Sleipner gave significant yield increases compared with single sprayings (Table 8).

Discussion

Earlier Danish experiments with variety mixtures of winter barley and spring barley has shown a reduction in the mildew attack (8,9). This reduction was also found in present experiments in winter wheat, especially in 1987 at both locations. In other experiments with variety mixtures in winter wheat the same results were obtained (6).

The level of yellow rust was in 1989 reduced in the mixtures at both locations where the maximum reduction was about 72% at Rønhave. The same effect was found by *Pope* (5) in mixtures with three varieties inoculated with a single isolate of yellow rust. It is remarkable that in 1988 no attack of yellow rust was recorded in Sleipner but in 1989 it was severely damaged with 75% of leaf area destroyed at the end of June. In the same year, 1989, there was no yellow rust in Sleipner at Roskilde whereas in Kraka, 50% attack was observed. This difference between the two locations may be due to differences in the virulence spectra of yellow rust because Sleipner has the specific resistance gene YR9. Also in English experiments it has been shown that the frequency of the corresponding virulence gene YV9 is increasing (2).

Also the latest Danish experiments testing varieties show an increasing level of yellow rust in Sleipner (7). The »Plant Protection Bulletins« from the Danish Research Centre for Plant Protection also report increasing attacks of yellow rust in this variety.

Attacks of *Septoria tritici* were especially severe i 1987 where the disease level at Rønhave was high in Citadel and Sleipner. The effect of mixture was neither significant at Rønhave nor at Roskilde. These results do not agree with those of *Karjalainen* (4), who used artificial inoculation with *S. nodorum* and unlike our experiments there was only one pathogen, *Septoria tritici* present whereas in this experiment, especially in 1987, mildew occurred as a another pathogen.

The difference in yield between three and four component mixtures was not significant. These results do not agree with German experiments, e.g. (6) showed that three comp. mixtures were better than four comp. mixtures.

Table 8. Yield relations hkg/ha. Roskilde 1989.

Variety	Without fung. appl.	Effect of mixtures	Fungicide treatment		
			Growth Stages 7-8 (Feekes)	Growth Stage 10.1 (Feekes)	Growth Stages 7-8 + 10.1 (Feekes)
1. Citadel	75.0		78.4	77.4	78.7
2. Kosack	65.6		66.4	67.9	69.0
3. Kraka	52.1		62.6	60.3	68.3
4. Sleipner	79.8		83.1	83.3	91.3
5. 1+2+3+4	69.0	0.9 n.s.	70.5	70.0	72.1
6. 1+2+3	67.2	2.9	70.7	70.8	72.4
7. 1+3+4	67.7	–1.3	72.9	71.4	76.9
8. 2+3+4	62.2	–3.6	68.5	67.3	73.7
9. 1+2+4	70.2	–2.9	72.8	71.8	76.9
Av. 1-4	68.1		72.6	72.2	76.8
Av. 6-9	66.9		71.2	70.3	75.0
Av. 1-9	67.9		72.0	71.3	75.7

LSD_1 (variety/mixture): 3.4 LSD_2 (mixture/average of 4-varieties): 2.7 LSD_3 (mixture/average of 3-varieties): 2.8 LSD_4 (treatment/effect of fungicides): 1.4 LSD_5 (treatment/variety or mixture): 3.5

Even if the experiments with mixtures showed a reduced level of attack, they did not give significant yield increases except at Rønhave in 1989 where also the reduction of yellow rust in the mixtures was pronounced. The reason why this was not found in 1987 and 1988 is probably that other parameters than diseases may determine the yield level. For instance the straw length of the individual variety may be of importance in the competition with the other varieties and often the varieties have different straw lengths in the mixtures. As an example the straw length of Sleipner is 70 cm and of Kosack 108 cm (7) which may cause differences in the light energy received in the mixtures and thereby affect the competitive ability.

Other Danish experiments have, as opposed to the present results, given pronounced yield increases. In 11 local experiments with mixtures (7) the average yield increase was 3.2 hkg/ha (5% increase) in mixtures of the varieties, Kraka, Sleipner, Urban and Gawain. The variation of the straw length is smaller than in our experiments.

Fungicide application in single varieties and mixtures gave, with a few exceptions, significant yield increases. In the mixtures the best effect was recorded at Rønhave with 12 hkg/ha but generally the mixtures yielded less compared with the average of single varieties. This tendency was more distinct at Rønhave than at Roskilde. Rust susceptible single varieties gave bigger yield increases than resistant varieties as Citadel and Kosack. The average of nine fungicide sprayed treatments showed a slight but nonsignificant difference between time of spraying whereas two sprayings gave a significant yield increase at both locations and at Roskilde a doubling of the yield increase in 1989.

The question is whether the use of mixtures can replace a single fungicide spraying? An answer to this can be obtained by evaluating the effect of mixture without fungicide treatment and the average fungicide effect of the varieties in pure stand. In this experiment it was not possible to use mixtures as a substitute for fungicide spraying. The effect of fungicide treated mixtures has also been investigated by *Gieffers* and *Hesselbach* (3) and *Ullerup* (7).

Ullerup concludes that spraying of mixtures yield less than average of treated single varieties. A direct comparison is not possible because three sprayings were used. Our results showed no significant differences.

Gieffers and *Hesselbach* (3) found that the yield in untreated mixtures was the same as the average of treated single varieties, as opposed to our results showing a lower level for the mixtures.

Conclusion

The experiments have shown interesting trends towards reduction in disease level especially when diseases as mildew and rust are severe.

The economic benefit of variety mixtures has been doubtful but further experiments should prove if this is the right answer.

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