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EVALUATION OF THE EFFECT OF PLANT GROWTH REGULATORS AND FUNGICIDES ON LIGHT INTERCEPTION, GROWTH AND YIELD OF OILSEED RAPE

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EVALUATION OF THE EFFECT OF PLANT GROWTH REGULATORS AND FUNGICIDES ON LIGHT INTERCEPTION, GROWTH AND YIELD OF OILSEED RAPE

by

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Summary

In 1996, four triazole-based fungicides and three conventional plant growth regulators were tested for effects on canopy structure, crop growth and seed yield of autumn-sown oilseed rape at ADAS Rosemaund and The University of Nottingham. At both sites, the fungicide Folicur, applied during early stem extension, reduced stem growth and lodging, increased canopy erectness and significantly increased the seed yield on crop samples harvested by hand prior to combining. These increases resulted from improvements in pod and seed retention particularly in the lower half of the pod layer. There were also important increases in harvest index showing that Folicur had improved the pattern of biomass distribution. When harvested later, by plot combine, there was no significant difference in yield between the control and Folicur. It appears most likely that the plots treated with Folicur ripened earlier and shed a larger proportion of seed in the period between the hand harvest and combining.

There was no evidence that either the proprietary growth regulators or other fungicides tested were effecting combine yields at either site. At ADAS Rosemaund in the hand harvested samples there was a small yield increase of about 0.4 t/ha (not statistically significant) from both Opus and Cerone. Although not significant in this case this may be worthy of further investigation.

This project has provided direct evidence that, in the absence of effects on disease, some fungicides can improve yield by increasing the productivity of the pods lower in the pod canopy. Folicur increased light penetration through the canopy but the magnitude of this improvement was small and unlikely to account for all of the increase in seed yield. The reduction in stem growth appeared to limit pod number and in so doing, may have increased the assimilate available for the earlier initiated pods at the base of the crop, and thus improved initial seed set. Before these potentially valuable effects from fungicides with growth regulating properties can be reliably incorporated into systems of rape production, the effects on canopy manipulation must be more fully investigated to identify the underlying physiological mechanisms, and thus identify crops likely to respond.

Introduction

Although large yield responses from the use of plant growth regulators and from fungicides applied in the absence of significant pressure from lodging and disease have often been reported (Rawlinson et.al. 1989; Stafford et al., 1995 and Spink, 1995) the responses have been inconsistent. The consistency of response could be improved by identifying crops most likely to show a positive response to treatment and to withhold treatment from those least likely to benefit. However, this will not be possible until the physiological mechanisms underlying the yield improvements from growth regulating chemicals have been identified. Recent work at the University of Nottingham (McWilliam, *et al.* 1995) has already led to a better understanding of the processes controlling yield formation in rape. It is emerging that the prevention of excessive growth in the period before flowering can optimise canopy architecture and improve the distribution of the intercepted radiation thus increasing pod and seed retention in the lower regions of the pod bearing canopy. This improvement in the understanding of yield formation in rape is being put to the test in an HGCA / MAFF funded project Canopy management in oilseed rape (OS06/01/95). This project will identify whether or not the productivity of the pod canopy can be optimised by altering husbandry, i.e. sowing date, seed rate and by spring applications of fertiliser N. In practice it is possible there may be situations where crop management may fail to restrict canopy expansion and in these crops, the use of plant growth regulators or fungicides with growth regulating properties offers growers a further chance to improve canopy architecture.

Objectives

The objectives of this experiment were to test a range of approved and experimental plant growth regulators and triazole fungicides for:

manipulation of canopy architecture
effects on light interception and distribution
pod and seed survival
seed yield

Materials and methods

Experimental design

Field experiments were set up at two sites; ADAS Rosemaund, Herefordshire and The University of Nottingham, Sutton Bonington, Leicestershire. Each experiment consisted of 7 treatments plus an untreated control, arranged in a randomised block design with 4 replicates at Rosemaund and 5 at The University of Nottingham. Plot size at both sites was 4m by 24m.

Table 1. Treatment applications of fungicides and plant growth regulators (l product/ha)

	Product	Timing	
		Stem Extension	Early-Mid flower
1.	Untreated	-	-
2.	Folicur early	1.0	-
3.	Folicur late	-	1.0
4.	Sportak 45	1.1	-
5.	5C Cycocel	3.0	-
6.	Moddus	1.2	-
7.	Opus	1.0	-
8.	Cerone	1.0	-

The products were chosen on the basis that growth regulatory effects had been reported elsewhere or in the case of the newer products that effects may be expected. The use of any of these products does not imply that they are approved for growth regulation in oilseed rape or that the product is approved for use on oilseed rape.

Levels of disease in the crop were kept to a minimum, using protectant non-systemic fungicides that were least likely to affect crop growth. All other inputs were applied at a level not to restrict crop growth and yield.

Measurements

Combine yield was measured at both sites by taking a 2.25 m wide strip from the centre of each plot, with a Sampo 2025 plot combine fitted with a bed extension to minimise combine losses.

Crop growth and yield component analysis was carried out pre-harvest at both sites at the latest timing that samples could be removed without significant loss of seed. This was done on Folicur and control plots at The University of Nottingham and on all plots at ADAS Rosemaund. During yield formation the percentage of incident photosynthetically active radiation (PAR) intercepted by the crop was measured at critical heights in the crop canopy using a pair of ceptometers (Decagon devices).

Results and discussion

Yield

Combine harvested yield was significantly above the long term average at both sites with 4.75 and 4.37 t/ha at ADAS Rosemaund and The University of Nottingham respectively. The long term average yield for both sites being 3.50 t/ha. There were no statistically significant effects of PGR or fungicide treatments on combine yield (Table 2).

Table 2. Combine harvested yield (t/ha @ 91% dry matter) ADAS Rosemaund and the University of Nottingham.

TREATMENT	Yield t/ha	
	Rosemaund	The University of Nottingham
Untreated	4.78	4.30
Folicur early	4.80	4.33
Folicur late	4.89	4.33
Sportak 45	4.85	4.46
5C Cycocel	4.67	4.35
Moddus	4.76	4.36
Opus	4.87	4.52
Cerone	4.41	4.32
Mean	4.75	4.37
$p \leq 0.05$	NS	NS
SED	0.179	0.129
LSD (df)	0.372 (21)	0.265 (27)
CV(%)	5.3	4.7

ADAS Rosemaund growth analysis

Table 3. Pre-harvest biomass and the components of yield, ADAS Rosemaund.

		Top of pod layer		Bottom of pod layer		Total				
						Biomass (t dm/ha)				Pod
Treatment	Plant No's/m^2	Seeds/ Pod	TSW (g)	Seeds/ Pod	TSW (g)	Total	Pod	Haulm	Seed	No's/m^2
Untreated	54.3	19.02	4.57	16.83	4.45	12.66	2.67	6.47	3.52	4659
Folicur Early	63.5	18.96	4.68	18.78	4.21	15.34	3.23	7.51	4.59	5690
Folicur Late	59.0	18.58	4.52	18.73	4.24	14.06	3.03	6.80	4.24	5352
Sportak 45	53.8	20.01	4.67	18.83	4.14	12.61	2.44	6.65	3.52	4334
5C Cycocel	57.0	18.08	4.56	16.68	4.11	12.95	2.86	6.53	3.56	5108
Moddus	46.3	19.51	4.77	17.47	4.33	12.77	2.71	6.56	3.50	4582
Opus	55.5	19.47	4.57	19.11	4.26	14.47	3.04	7.51	3.92	4891
Cerone	55.8	19.87	4.68	18.95	4.22	12.67	2.71	6.07	3.89	4672
Mean	55.6	19.19	4.63	18.17	4.24	13.44	2.84	6.76	3.84	4911
$p \leq 0.05$	NS	NS	NS	0.073	NS	0.083	NS	0.121	0.061	0.104
SED	6.52	1.144	0.150	0.956	0.168	1.008	0.295	0.519	0.370	447.6
LSD (df = 21)	13.56	2.380	0.312	1.989	0.349	2.097	0.614	1.080	0.770	931.0
CV%	16.6	8.4	4.6	7.4	5.6	10.6	14.7	10.9	13.6	12.9

The hand harvested yields at ADAS Rosemaund indicated that application of Folicur gave an almost significant ($p = 0.061$) 1.07 or 0.72 t dm/ha yield response applied at stem extension or early flower respectively (Table 3). Analysis of the components of yield shows that this was due to a combination of an increase in pod number per unit area and an increase in the seed number per pod lower in the canpoy. Other treatments affected either pod number (5C Cycocel) or increased seed number per pod in the lower pods (Sportak 45, Opus and Cerone). None had the dual effect of the early application of Folicur, and had little or no effect on yield (Table 3).

Table 4. Photosynthetically active radiation (PAR) reflected and intercepted at the base of the crop and middle of pod layer (%), ADAS Rosemaund, 16 May 1996.

	% PAR Interception at:		
Treatment	Base of crop	Middle of Pod Layer	Reflected
Untreated	99.31	71.67	12.76
Folicur Early	99.06	68.93	11.92
Folicur Late	99.06	71.03	12.90
Sportak 45	99.44	69.05	12.85
5C Cycocel	99.32	70.39	10.85
Moddus	99.16	71.73	10.09
Opus	99.29	64.64	12.07
Cerone	99.22	68.45	12.00
Mean	99.23	69.49	11.93
p	NS	0.084	0.003
SED	0.158	2.254	0.653
LSD	0.329	4.688	1.358
(df = 21)			
CV%	0.2	4.6	7.7

The increase in seed number per pod in the lower portion of the canopy following early application of Folicur and the increased final pod number (possibly indicating reduced pod abortion) are both comensurate with improved light penetration into the canopy. There was an indication in the early stages of pod fill that some of the treatments (Opus, Cerone and Folicur) resulted in increased light penetration to the lower pod layers (Table 4). Later in pod fill, once final pod numbers were set and abortion of excess pods had ceased, these differences were no longer apparent (Tables 5 & 6).

Table 5. PAR reflected and intercepted at the base of the crop, bottom of green leaf layer, and bottom and middle of pod layer (%), ADAS Rosemaund, 11 July 1996.

	% PAR Interception at:				
Treatment	Base of crop	Bottom of green leaf layer	Bottom of pod layer	Middle of pod layer	Reflected
Untreated	93.3	91.2	88.1	72.5	9.7
Folicur early	92.3	89.2	86.4	72.5	11.6
Folicur late	92.2	89.7	88.5	71.7	10.6
Sportak 45	91.7	90.0	88.3	72.4	12.0
5C Cycocel	90.3	87.6	84.1	65.9	11.7
Moddus	92.3	89.3	86.5	69.9	10.1
Opus	91.4	88.7	85.3	68.2	11.8
Cerone	88.8	85.8	81.3	66.2	12.1
Mean	91.6	88.9	86.0	69.9	11.2
p	0.034	0.069	0.090	NS	NS
SED	1.202	1.528	1.56	4.35	1.27
LSD (df = 21)	2.500	3.178	3.25	9.05	2.64
CV%	1.9	2.4	2.6	8.8	16.0

Table 6. PAR reflected and intercepted at the base of the crop, and bottom and middle of pod layer (%), ADAS Rosemaund, pre-harvest 1996

	% PAR Interception at:			
Treatment	Base of crop	Bottom of pod layer	Middle of pod layer	Reflected
Untreated	85.1	80.9	69.7	8.0
Folicur early	87.2	82.1	69.8	7.8
Folicur late	86.4	81.2	68.6	7.8
Sportak 45	85.3	81.3	64.1	8.1
5C Cycocel	87.0	82.9	72.2	8.0
Moddus	86.3	81.9	66.9	7.8
Opus	85.6	79.6	65.8	8.0
Cerone	84.5	78.6	66.2	8.2
Mean	85.9	81.1	67.9	8.0
p	NS	0.088	NS	NS
SED	1.09	1.35	3.56	0.19
LSD (df = 21)	2.67	2.81	7.40	0.40
CV%	1.8	2.4	7.4	3.5

There were small but significant effects of some of the treatments on crop height (Table 7). The traditional growth regulators 5C Cycocel and Cerone had the greatest shortening effect, however, these only shortened the crop by 7 and 6 cm respectively. Shortening was not related to yield and no treatment altered the depth of the pod layer, indicating that the crop shortening effect was most probably due to restricting earlier vegetative growth resulting in a similar pod layer supported on shorter stems.

Table 7. Crop heights (m) pre-harvest, ADAS Rosemaund

	Crop height (m) to:		
Treatment	Top of crop	Middle of pod layer	Bottom of lod layer
Untreated	1.75	1.49	1.25
Folicur Early	1.71	1.45	1.20
Folicur Late	1.72	1.47	1.22
Sportak 45	1.75	1.49	1.24
5C Cycocel	1.68	1.43	1.18
Moddus	1.73	1.47	1.22
Opus	1.72	1.45	1.20
Cerone	1.69	1.45	1.21
Mean	1.72	1.46	1.21
p	0.008	0.001	0.002
SED	0.017	0.013	0.013
LSD (df = 21)	0.035	0.027	0.027
CV%	1.4	1.2	1.5

The University of Nottingham growth analysis

At The University of Nottingham as at Rosemaund the early application of Folicur produced a yield increase, on the hand harvested samples (Table 8). The response was smaller at The University of Nottingham in the order of 0.4 t/ha. Pre-harvest biomass and yield component analysis was therefore concentrated on the early Folicur treatment, this being the only treatment to visibly affect crop structure. The majority of the crop suffered early and severe lodging and final crop height was on average only 0.75 m (Table 9). The early Folicur treatment had a significant effect in shortening the crop and delaying the onset of lodging (Plates 1 & 2). As at ADAS Rosemaund, PAR interception (Table 10) by the crops in the later stages of pod fill (and post lodging) did not appear to account for differences in yield. At The University of Nottingham the severe and differential timing of lodging made it impossible to sample the pods that had filled at the top and bottom of the canopy. The sampling carried out at this site a few days prior to combine harvesting does however, suggest why differences in crop yield were measured by hand harvest and not combine harvest. The seed yield from hand-harvested samples of the control and Folicur treatments which had not shed were similar at 3.66 and 3.68 t/ha @ 100%dm respectively. However, collection of seed shed during the sampling process showed that the Folicur treatment was more prone to shedding, the yield advantage of the treatment being lost in seed shed in the period between sampling and harvest. The Folicur treated crop was more erect than the rest of the crops for the majority of pod filling and ripening and would be expected to ripen more rapidly due to greater air circulation in the canopy. This more rapid ripening in combination with harvest being timed for the majority of the crop which was lodged appears to have increased the shedding losses from the Folicur treatement. Given correct timing of harvest for this one treatment the potential yield advantage would expect to be realised.

Table 8. Pre-harvest biomass and components of yield, The University of Nottingham.

Crop components	Dry matter (t/ha)	
	Control	Folicur
Stem	6.53	6.02
Seed (in pods)	3.66	3.68
Seed (shed)	0.58	0.94
Pod walls	2.29	2.14
Pod number/m^2	7313	6581
Total seed	4.24	4.68
Total	13.06	12.84
Harvest index	32.45	36.44

Table 9. Crop heights (m). The University of Nottingham pre-harvest.

	Height (m)	
Treatment	To top of crop	To base of pod layer
Untreated	0.62	0.47
Folicur early	0.77	0.58
Folicur late	0.71	0.54
Sportak 45	0.78	0.58
5C Cycocel	0.75	0.58
Moddus	0.74	0.50
Opus	0.87	0.61
Cerone	0.76	0.56
Mean	0.75	0.55
p	NS	NS
SED	7.66	5.27
LSD (df = 28)	15.69	10.79
CV%	16.1	15.1

Table 10 PAR interception The University of Nottingham Pre-harvest 1996.

	% PAR intercepted at:			
Treatment	Bottom of crop	Bottom of pod layer	Middle of pod layer	Reflected
Untreated	93.6	92.4	77.2	9.2
Folicur early	95.6	96.0	80.4	7.8
Folicur late	95.2	94.6	84.2	8.4
Sportak 45	96.4	95.0	80.0	8.6
5C Cycocel	94.6	92.8	80.6	8.8
Moddus	95.0	94.0	78.8	8.6
Opus	96.2	95.2	83.8	8.2
Cerone	94.6	93.4	77.8	8.8
Mean	95.15	94.17	80.35	8.55
p	NS	NS	NS	NS
SED	1.129	1.404	2.995	0.513
LSD (df = 28)	2.312	2.875	6.134	1.051
CV%	1.9	2.4	5.9	9.5

Plate 1. The University of Nottingham, Untreated control plots displaying severe lodging - 23 July 1996.

Plate2. The University of Nottingham, Early Folicur plots displaying reduced and delayed lodging - 23 July 1996.

Conclusions

In this pilot work on PGR's and fungicides there were strong indications that a number of the treatments investigated had potentially beneficial effects on crop growth and yield. It is also noticable that the triazole fungicides appeared to have a greater effect on crop growth than some of the proprietary growth regulators approved for use on oilseed rape. Within the triazoles there was a range in the growth regulatory effects of the different active ingredients. Folicur (tebuconazole), when applied during stem extension, appeared to have the most consistent and greatest effect on crop growth, although it also had an effect when applied as late as full flower.

The growth regulatory effects of these chemicals, particularly the effects observed from late applications of Folicur, present the opportunity to the grower to manipulate the growth of the oilseed rape crop well into the spring and summer. This improves the chances for the grower to exploit the understanding of yield formation in the oilseed rape crop currently being tested in project OS06/01/95. In that project the techniques currently under investigation (sowing date, seed rate, defoliation and nitrogen) are largely decided in the autumn and winter and in the case of the nitrogen early spring.

It is clear from previous work where the responses were not consistent that not all crops are likely to give a yield benefit. Further work is therefore required to understand the mechanisms involved in producing the yield response. Once these are known, those crops most likley to benefit can be identified. It may also be possible given an understanding of the underlying processes to alter timing or rates of the products according to the crop condition, to gain the maximum benefit to the grower.

Recomendations

1/ There is interest within the industry in using these products to regulate the growth of oilseed rape not only to gain a yield response but also to aid harvesting by reducing lodging. The products are being used both alone and in tank mixes without clear guidelines on the basis of 'hunch'.

2/ Given the frequently observed large variation in response to these types of chemical there is a need to understand more fully their mode of action and therefore the crops and varieties most likely to give an economic return. When targetted correctly the increased profit to farmers would be large in relation to expenditure resulting in an extremely favourable cost benefit ratio.

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