YIELD IMPROVEMENT THROUGH CANOPY MANAGEMENT

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ABSTRACT

This paper outlines the on-going work at The University of Nottingham and ADAS to improve the profitability of autumn-sown oilseed rape by improving yields and minimising the costs of production. The 'Canopy Management' approach is to grow crops with post-flowering canopies smaller than the commercial norm and thus avoid the production of profuse foliage in dense layers which leads to poor penetration of light to the lower pods resulting in severe mutual shading, heavy pod and seed abortion, and low, variable yields. The theoretical optimum canopy size during seed filling was estimated to be about 3.5 units of green area index. Where fertiliser N was adjusted to achieve crop structures close to the optimum this improved yields. At The University of Nottingham in 1996, restricting canopy size to 3 GAI during early seed filling improved yield by 0.4 t/ha. The crop intercepted slightly less radiation than the more dense crop, producing slightly less biomass at final harvest, but this was partitioned more efficiently to seed. Lower plant populations have also proved a effective way of improving canopy structure. However, the ability to manipulate canopies more fully through a combination of both plant population and nitrogen requires that established plant populations be produced more reliably.

KEYWORDS

Oilseed rape, canopy structure, light interception

INTRODUCTION

Oilseed rape is the third most widely grown combinable crop in the UK but yields are often variable and disappointing, especially where there has been vigorous early season growth. McWiliam *et al*. (1995) demonstrated that yield formation could be related to the structure of the rape canopy after flowering: less thick pod canopies allowed more light to penetrate to the lower pods, seed abortion was reduced and yields improved. This paper presents an overview of the work in progress at The University of Nottingham and ADAS to exploit this understanding by examining the potential for achieving high yields more consistently through optimising the size of the crop's canopy in spring. Part of this work has focused on 'Canopy Management' with judicious use of fertiliser N to supplement the supply of nitrogen from soil to ensure adequate, but not excessive, expansion of the photosynthetic surface.

CANOPY MANAGEMENT

Detailed analyses of Capricorn winter rape (Figure 1) have shown that seed formation must result from photosynthesis after the end of flowering (mid-May) (Stafford, 1996); dry matter from stems is not retranslocated and, although the weight of leaves declines, most is associated with leaf fall; only a small proportion might be retranslocated to the lowest pods. The only significant retranslocation that does occur is during late seed filling from pod hulls. Therefore, because rape appears to only have a small 'buffer' to supplement shortfalls in photosynthesis during pod filling, it would be expected that the implications of excessive canopy growth and poor light distribution on yields would be severe but conversely, the potential benefits from Canopy Management would be large.

Theory

The underlying philosophy of the Canopy Management approach for winter wheat has been set out by Sylvester-Bradley *et al*. (1998). With wheat, the target is to regulate the expansion of the crop's canopy to provide for adequate light interception after flowering because between 70% or so of the yield is derived directly from photosynthesis during grain filling; the rest comes from remobilisation of soluble carbohydrates stored in stems before flowering.

For winter wheat, the starting point was to calculate the theoretical optimum size of canopy by calculating the return in yield (£) from each additional increment of fertiliser N. This was done through a series of quantitative steps (Sylvester-Bradley *et al*., 1998). If the yield of oilseed rape is directly linked to the activity of the crop's canopy after flowering, the same underlying theory can be used to determine the optimum canopy size. From our work to date, and from the scientific literature, we estimated the following parameters to allow an estimate to be made of the optimum canopy size:

- fertiliser N is recovered with 60% efficiency
- each hectare of green surface requires 50 kg/ha of N to be taken up (Figure 2)
- the canopy intercepts radiation according to Beer's Law with an extinction coefficient of 0.75 (Figure 3)
- the seed filling phase lasts for 35 days with 18 MJ/m^2/day (Figure 1)
- each MJ of light is converted into 0.6g of seed
- seed is sold at 9% moisture for £160 per tonne
- fertiliser N costs £0.3 / kg N

Using these parameters, the theoretical optimum canopy size during seed filling was estimated to be about 3.5 units of green area index (GAI).

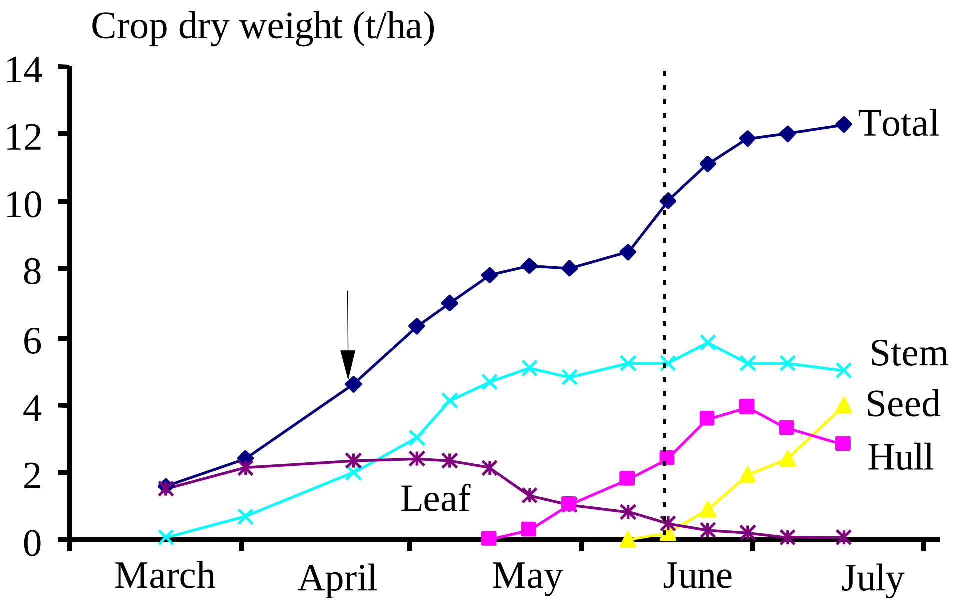

Figure 1: Partitioning of crop dry weight in winter rape cv. Capricorn. Arrow indicates the onset of flowering. The dotted line shows the start of seed filling.

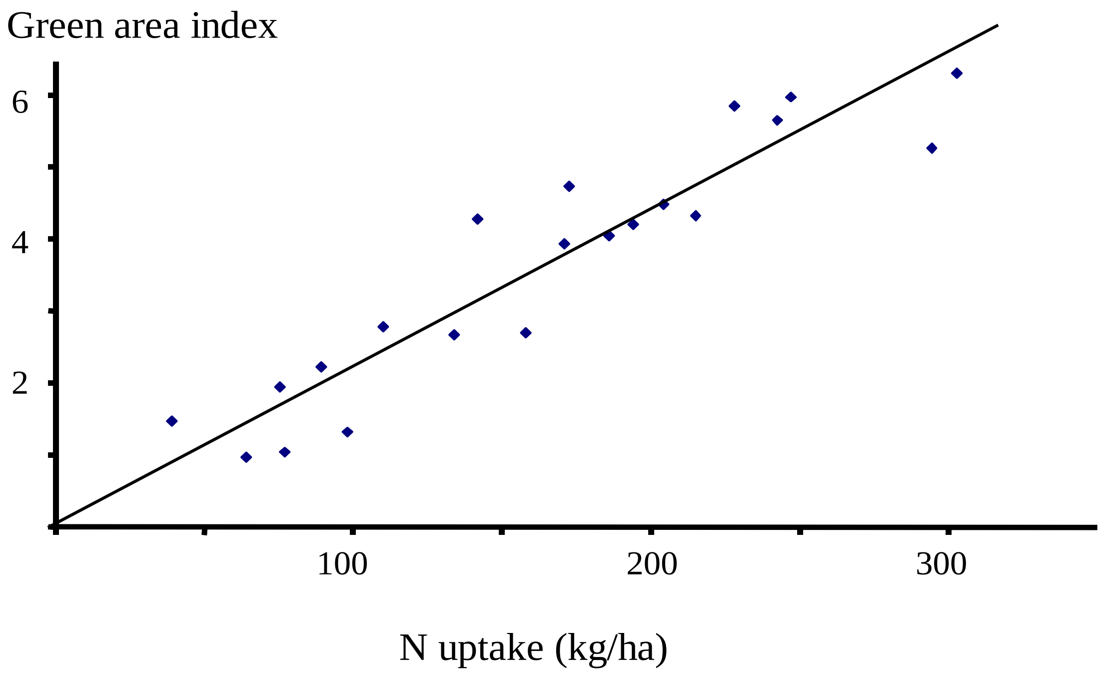

Figure 2: Relationship between uptake of N and expansion of the green canopy of winter rape cv. Apex. The slope of the line is equivalent to 50 kg/haN per ha of green area.

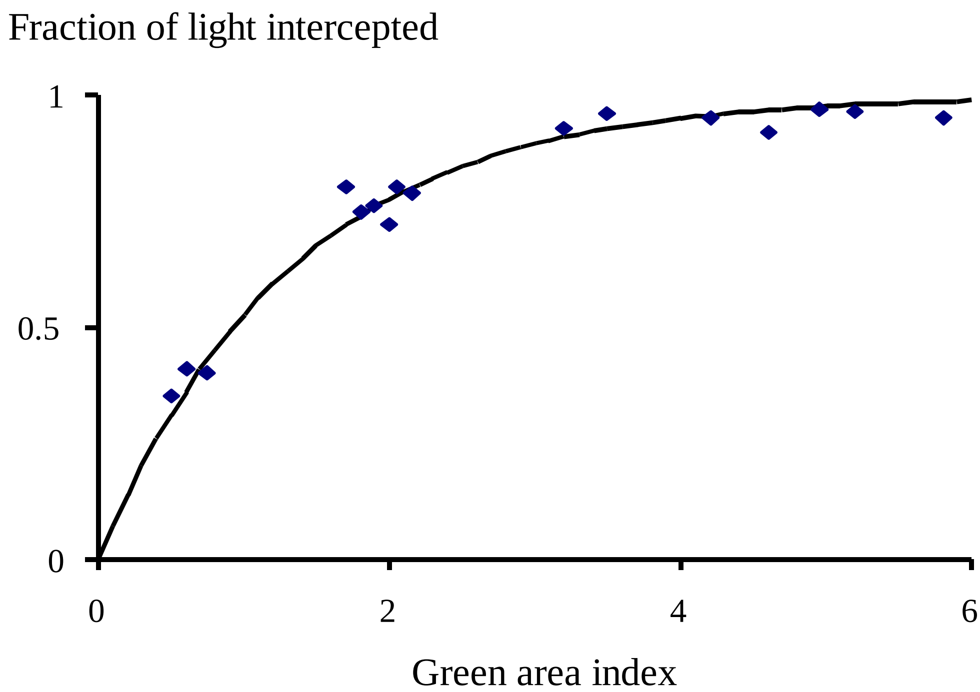

Figure 3: Effect of canopy size on the fraction of the incident light intercepted by winter rape cv. Apex. The line represents the extinction coefficient of 0.75.

Evidence

The concept of an optimum canopy size is being tested for Apex winter rape by manipulating canopy structure by sowing early and late, at high and low plant population and with and without partial defoliation in January. These treatments have produced crops with variations in maximum canopy size at growth stage 5.9 - 6.1 (mid June) from 4 GAI to about 7 GAI. Interestingly, examination of the pod bearing layers of the crops yielding more than 4.5 t/ha has shown that they have pod layers of only 2.5 GAI of which most is pod and stem (Table 1).

Table 1: The mean size of the photosynthetic components in the pod layer in mid-June of crops of winter rape cv. Apex which produced more than 4.5 t/ha of seed at harvest.

	Green Area Index (mid pod filling)			
	Pod	Stem	Leaf	*Total*
Mean of 3 crops	1.6	0.7	0.2	*2.5*

Where we have adjusted applications of fertiliser N to achieve crop structures close to the optimum, this has improved yields. For example, at The University of Nottingham in 1996, restricting canopy size to 3 GAI during early seed filling improved yield by 0.4 t/ha. The crop intercepted slightly less radiation than the more dense crop, producing slightly less biomass at final harvest, but this was partitioned more efficiently to seed (Table 2).

Table 2: Effect of manipulation of canopy size in mid-June on radiation interception, total crop dry weight, harvest index, seed yield, pods per m^2, seeds per pod and thousand seed weight of winter rape cv. Apex.

	Crop 1	*Crop 2*
Canopy size in mid June (GAI)	3	5
Radiation interception (%)	90	95
Total crop dry weight (t/ha)	14.5	15.5
Harvest index (%)	30	26
Seed yield (t/ha 9%)	4.8	4.4
Pods / m^2	6800	8400
Seeds / pod	14	10.8
Thousand seed wt (g)	4.8	4.8

The reduction in canopy size was achieved through a reduction in the number of pods but this was more than offset by an increase in the survival of seeds per pod: individual seed weight was not affected.

DISCUSSION

There appears to be sufficient flexibility in oilseed rape to manipulate canopy size to optimise the distribution of radiation within the pod canopy. In addition to control with fertiliser N, canopy size can be regulated through plant population: thin crops resulting from few but uniformly spaced plants have the potential to yield well. McWilliam *et al*. (1995) and McWilliam (1998) showed that plant populations as low as 7 plants per m^2 can produce similar yields to populations of 60 and 120 plants per m^2 provided the plants were uniformly spaced. However, although there may well be an optimum plant population to form the optimum size of canopy, this is currently difficult to achieve because of variable establishment, especially on the heavy clay soils on which rape is grown in the UK. Therefore, other on-going research is examining the potential for improving establishment of oilseed rape so that we can more confidently aim for the optimum population.

It is envisaged that reliable, uniform establishment of a predetermined plant population, in combination with managed nitrogen applications, will provide the mechanism for more precise control over canopy size and that this will result in more consistent yields of oilseed rape.

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ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support from HGCA and MAFF.

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