Physiological Factors controlling the yield of Oilseed Rape

Paul E. Bilsborrow and Grenville Norton

Department of Applied Biochemistry and Food Science,
University of Nottingham School of Agriculture,
Sutton Bonington, Nr. Loughborough, Leics. LE12 5RD., U.K.

#### Introduction

Although the yield of oilseed rape has increased in recent years through the introduction of higher yielding cultivars and improvements in agronomic procedures, the final yield is lamentably low and extremely variable from one season to another. Average yields of 3 tonnes per hectare were reported by Shipway (1981) for rapeseed trial material over a period of seven years. Compared with cereals, rapeseed is an inefficient seed producer. Harvest indices for early-autumn sown rapeseed (older unimproved types) ranged from 14-28% over seven seasons (Mendham, Shipway and Scott, 1981) and only marginal improvements on these have been recorded for recently introduced cultivars (Bilsborrow, 1985).

Final seed yield is determined by a number of contributing factors including pod numbers, seed numbers per pod and individual seed weight. Appreciable losses of flowers and pods occur throughout plant development (Mendham, Shipway and Scott, 1981; Norton and Shipway, unpublished observations). These losses have been attributed to limiting supplies of assimilates at critical stages of development caused by the reflection of light at flowering and mutual shading throughout pod and seed development (Allen and Morgan, 1975; Mendham, Shipway and Scott, 1981). Experimental verification of these proposals has not been presented.

Unfortunately studies on which factors control pod and seed development and ultimately yield during the growth and development of the crop have been either superficial or incomplete. The work to be reported here in preliminary form represents an attempt to obtain information as to how and when the individual components of yield are determined. The approach used was to ascertain the relative contributions of different plant parts to dry matter and green area at different levels within the crop. Radiation and

detailed gross photosynthesis measurements within the crop profile taken in conjunction with the green area distribution should yield quantitative data concerning the major photosynthetic sites within the crop throughout development. Such information should enable the identification of factors governing pod and seed losses and provide guidance for future breeding and crop manipulation strategies.

# Experimental and discussion

A series of experiments over a three year period was carried out using commercial crops of <u>Brassica napus</u> spp <u>oleifera</u> cv Rafal grown at different locations on the University of Nottingham farms. Detailed growth analysis was carried out weekly using a stratified sampling technique of successive 20cm layers of l-square metre area, from ground level to the top of the crop. Total radiation and photosynthetically active radiation (PAR) were obtained using either tube solarimeters or quantum sensors respectively situated at different heights within the crop. Gross photosynthesis was measured using modifications of the technique of Incoll (1977).

Growth and development of autumn sown oilseed rape can be divided into four distinct phases:

#### 1. Vegetative.

Leaf expansion and stem elongation resulted in the formation of good ground cover enabling the efficient utilisation of incident radiation and the formation of a good root system. The potential yield of the crop was found to be determined by the size of the plant at the end of this phase <u>viz</u> the onset of flowering (Mendham, Shipway and Scott, 1981). The potential yield is moderated by events in subsequent growth phases.

2. Development of the reproductive framework of the plant and flowering.

This phase is initiated by flowering and ends when maximum stem area and weight is attained but prior to appreciable pod development. Flower, pod and seed losses during this period were heavy when leaf area, particularly in the lower horizons of the crop profile, was declining rapidly. Further, much of the leaf tissue situated below the flower canopy was in deep shade. Radiation measurements throughout the profile revealed that around peak flowering about 50% and 20% of the total incoming radiation and PAR respectively were reflected by the crop. Approximately 80% incident PAR was

absorbed by the flower bearing layers which were found to be inefficient in photosynthesis. Thus it may be concluded that flower and pod (including seed) losses during this development stage were due to limitations of assimilate supplies provided in the main by leaf photosynthesis especially in horizons immediately below and including the lowest flower bearing layer. These observations are in qualitative agreement with those of Chapman, Danielf and Scarisbrick (1984).

### 3. Fod development.

Maximum pod area and weight was obtained during this phase resulting in the formation of a dense pod canopy (top 40cm of crop) which at the end of this development stage was absorbing 84% of the incident PAR. Also at this time almost all the leaf tissue below the pod canopy had senesced. Any leaf tissue remaining consisted of bract-like leaves in the lower region of the pod bearing canopy. Thus pods and pod bearing branches constituted the major photosynthetic tissues as pod development neared its completion (over 80% gross photosynthesis). In absolute terms the gross photosynthetic capacity of the crop had declined to approximately 55% of that in phase 2.

Pod numbers continued to decline so that by the end of this developmental stage only 60% of the potential pods remained. Pod losses were progressively more severe in the lower regions of the pod canopy presumably through mutual shading from above.

It may be concluded that during this development phase, assimilates from leaf tissue declined to almost zero levels while the requirements for pod growth were met by pod and stem photosynthesis.

## 4. Seed development.

Dry matter accumulation, mainly oil and protein, occurred in the seeds on the completion of pod development. Limited pod and seed losses continued until at crop maturity and depending on the season, between 40-60% and approximately 30% of the potential pods and seeds remained. All the yield components, pod number, seed weight and seed numbers per pod, declined progressively down the profile. This decline was attributed to the limitations in photosynthate supply overall and in the lower layers of the pod bearing canopy in particular. In excess of 70% of available PAR was absorbed by the upper pod bearing strata (40cm) with only some 10% available to the lower layer (20cm). Pods and pod bearing branches accounted for over 95% of crop photosynthesis during this phase. Gross photosynthesis of the crop

declined throughout the period such that towards the end of this development phase it had declined to around 38% of the maximum rate (before peak flowering). Through phase 4 the pods were largely responsible for their own filling. On an area basis both pods and stems have a lower capacity for photosynthesis than leaf tissue even at this late stage of development. Dry matter remobilisation from within the plant was not evident during pod filling. It must be concluded that the ultimate seed yield is determined by the photosynthetic capacity of the pods and pod-bearing branches in phase 4.

In conclusion it has been shown that the potential yield of oilseed rape is determined in phase 1 of plant development. Throughout phases 2 and 3 this potential is modified by the availability of photosynthate and possibly other assimilates and is dependent upon climatic conditions throughout the period. The extent of photosynthesis in the final developmental stage determines the ultimate yield. Unless the efficiency of photosynthesis of the crop can be improved by either breeding or manipulation of plant growth, it is unlikely that substantial increases in the yield of cilseed rape can be expected.

#### References.

- Shipway, P.A., 1981. Factors controlling the yield of oilseed rape. (Brassica napus L). Ph.D. Thesis, University of Nottingham.
- Mendham, N.J., P.A. Shipway and R.K. Scott. 1981. The effects of delayed sowing and weather on growth, development and yield of winter oilseed rape (Brassica napus). Journal of Agricultural Science, Cambridge, 96:389-416.
- Bilsborrow, P.E., 1985. Physiology of yield production in oilseed rape.

  (Brassica napus L). Ph.D. Thesis, University of Nottingham.
- Allen, E.J. and D.G. Morgan, 1975. A quantitative comparison of the growth, development and yield of different varieties of oilseed rape. Journal of Agricultural Science, Cambridge. 85:159-174.
- Incoll, L.D. 1975. Field studies of photosynthesis monitoring with <sup>14</sup>CO<sub>2</sub>.

  In Environmental effects of crop physiology. Landsberg J.L. and
  C.V. Cutting, eds. 137-155. Academic Press, London.
- Chapman, J.F., R.W. Daniels and D.H. Scarisbrick, 1984. Field studies on <sup>14</sup>C assimilate fixation and movement on oilseed rape (<u>B. napus</u>)

  Journal of Agricultural Science, Cambridge. 102:23-31.