OILSEED RAPE: THE EFFECTS OF RATE, TIMING AND FORM OF NITROGEN APPLICATIONS ON A DEPLETED LISMORE SOIL

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ABSTRACT

Three trials were undertaken over two seasons to determine nitrogen requirements of Oilseed Rape (cv. Marnoo) on a nitrogen depleted site at Winchmore Irrigation Research Station.

In the 1986-87 season, the first trial examined five rates of nitrogen (0, 70, 140, 210 and 280 kg N/ha) applied either at drilling, stem extension or split between both dates. These treatments were applied to plots sown either in August or September. A second trial compared the relative effects of urea, ammonium sulphate and elemental sulphur on yield and oil content. In the 1987-88 season, the first trial was repeated but only the August sowing date was harvested.

Large increases in yields (up to two fold) were obtained with applied nitrogen. Nitrogen rates of 140 to 210 kg N/ha gave yields of up to 3.0 t/ha. Timing of nitrogen did not significantly affect yields, although rates above 140 kg/ha tended to be better split applied. The September sowing had higher yields than the August sowing, but less irrigation was required at the earlier sowing. Urea and ammonium sulphate gave comparable yields, but elemental sulphur did not increase yields.

A slight decline in oil content occurred with increasing rates of nitrogen and delaying nitrogen application until stem extension further decreased oil content. However, this was offset by the large seed yield increase giving an overall oil yield increase.

These results demonstrate that good yields can be achieved on a nitrogen depleted site. The optimum rate considering economic returns was 140 kg N/ha and this was best applied at drilling or split between drilling and stem extension.

Additional Key Words: Brassica napus, *cv. Marnoo, canola variety, spring, sowing date, seed yield, oil content, sulphur.*

INTRODUCTION

Historically, rapeseed has been a minor oilseed crop world wide, although reportedly it was among the world's first domesticated crops. In the past decade world production has increased substantially, mainly because of the development and use of new varieties low in both erucic acid and glucosinolates, coined 'double low' or 'canola' varieties (Paszkowski, 1984). These attributes make the crop desirable for high quality vegetable oil and the meal by-product is suitable for stock feed. This world trend has encouraged the recent development of an export industry in New Zealand with the main production coming from Canterbury. The area under production for export has increased from 350 ha in 1984/85 to 3400 ha in 1987/88 with prospects for further expansion (Bede McCloy, pers. comm.).

To the farmer the attractions of growing oilseed rape are two fold:

1. As a break crop for cereals, particularly to prevent the build-up of take-all and other problems associated with continuous cereals;
2. As an alternative crop to broaden the economic cropping base for arable farmers.

Previous work in New Zealand has shown that 75 kg N/ha gave a substantial yield increase over no nitrogen when oilseed rape followed cereal, but no yield response after pasture (Stoker and Carter, 1984). These results indicate that the farmer should apply nitrogen to oilseed rape in intensive cropping rotations, but not how much. In the United Kingdom, nitrogen recommendations for autumn oilseed rape are 200 kg N/ha after continuous cereals or equivalent depletive crops, 175 kg N/ha after annual legumes or equivalent, and 150 kg N/ha after long term pasture or equivalent (Ward *et al.*, 1985). For spring sown crops the recommendations are 50 kg/ha lower. In New Zealand, if other crops are a guide, the recommendations are likely to be lower than in Britain, although, in intensive cropping rotations, the previous recommendation of 50 kg N/ha (Davidson, 1976) may be too low.

High nitrogen levels, although increasing yield, can reduce the seed oil content by up to 2% per 100 kg nitrogen applied, and also can cause major harvesting problems due to lodging (Holmes, 1980). Most nitrogen is taken up by the oilseed rape plant over the stem elongation to late flowering period of growth. Recommendations for autumn sown crops in the United Kingdom are to put all nitrogen on just before stem elongation, except for some seedbed nitrogen for late sown crops or after cereals (Ward *et al.*, 1985). For spring sown crops the recommendation is half applied in the seedbed and half just before stem elongation. The recommendation in New Zealand has been to apply all nitrogen at sowing (Davidson, 1976), although split applications are recommended for rates over 60 kg/ha (Rankin, 1986). Nitrogen fertilizer recommendations for oilseed rape in New Zealand have specified ammonium sulphate (Davidson, 1976), except when split applications are used, in which case urea can be used for seedbed application but ammonium sulphate is recommended for topdressing (Rankin, 1986). Although oilseed rape has a higher sulphur requirement than other crops, because of the high content of sulphur-containing proteins, responses to sulphur have only occurred in those areas where there are major soil sulphur deficiencies (Holmes, 1980).

The cultivar most commonly grown in New Zealand, 'Marnoo', is an Australian bred example of the new 'double zero' or 'Canola' varieties (Anon., 1985) and here it is spring sown. In Australia the major sowing time for oilseed rape is May (Weiss, 1983). In the United Kingdom, the 'double zero' type of oilseed rape is unsuited to autumn or winter sowing because of frost damage. The earlier the crop can be sown in the spring in Britain, the higher the yield (Scarisbrick *et al.,* 1981). In New Zealand, recommended sowing dates have moved from late October (Davidson, 1976) to between mid September and mid October (Rankin, 1986). If other crops are a guide then still earlier sowing should result in yield increases.

There are still major gaps in the extension advice available to farmers on how to consistently produce high yields of export quality oilseed rape. Two areas where crop management recommendations are vague are nitrogen fertilizer (amount, timing and type) and sowing date.

MATERIALS AND METHODS

Three trials were undertaken over two seasons to determine nitrogen requirements of oilseed rape (cv. Marnoo) on a nitrogen depleted site at Winchmore Irrigation Research Station. The soil classified as a Lismore stony silt loam was prepared for irrigating by the border-strip method. Soil nutrient details are given in Table 1.

TABLE 1: Quick test, sulphur and nitrogen incubation levels.

	Year 1	Year 2
pH	6.6	6.2
Ca	15	12
K	8	8
P	18	19
Mg	10	11
Na	4	4
SO_4	6	7
Initial N.	8.2	12.3
Final N. (total)	37.6	27.1
YO*	3.8	2.7

*predicted yield of a cereal crop without applied N. (Quin *et al.,* 1982).

The first trial in Year 1 (1986/87) examined five rates of nitrogen (0, 70, 140, 210 and 280 kg N/ha), applied at three application times either at drilling, stem extension or split between both times except that 280 kg was not applied at drilling. These treatments were applied to plots sown either in August or September. This trial had treatments arranged in a modified split plot design with sowing dates by time of application as main plots and rate of nitrogen as subplots all replicated three times.

A second trial sown in September compared the relative effects of urea, ammonium sulphate, and elemental sulphur alone and in combination with urea. These nitrogen forms were applied at rates equivalent to 140 kg N/ha and elemental sulphur (10 mesh screen) at 160 kg/ha (equivalent to the rate of sulphur in ammonium sulphate). This trial comparing forms used a randomized block design replicated four times.

Details of actual sowing dates, nitrogen application dates along with other crop husbandry data are given in Table 2.

TABLE 2: Details of Plant establishment and crop husbandry operations.

	Year 1		Year 2
	Aug	Sept	Aug
Sowing date	1/8	23/9	12/8
Nitrogen Early (at drilling)	1/8	23/9	12/8
Application Late			
(stem elongation)	23/10	18/11	28/10
Plant Establishment (pl/m^2)	118	96	123
Irrigations	3	5	2
Aphicides	1	2	1
Windrowing date	31/12	21/1	2/1
Harvest date	12/1	30/1	14/1

The first trial was repeated in Year 2 (1987/88), but because of establishment problems associated with drilling equipment the September sowing was not harvested.

Plots on all trials were 28 m long x 1.5 m wide.

A pre-emergence herbicide (trifluran @ 1 kg/ha a.i.) was applied just prior to the final cultivation. The early nitrogen treatments were broadcast just prior to drilling 'Marnoo' rapeseed into a fine firm seedbed at 5 kg/ha along with 250 kg/ha of lime reverted superphosphate (recommended by Davidson (1976) and Rankin (1986)) and a systemic insecticide (disulfoton @ 0.5 kg/ha a.i.). The trial area was cambridge rolled immediately after drilling. The dates of major field operations are given in Table 2.

The crop was regularly monitored for gravimetric soil moisture in the top 150 mm and irrigated to maintain the soil above 50% depletion of available soil moisture. The number of irrigations are given in Table 2 (100 mm applied at each irrigation). An aphicide (Pirimicarb @ 250 g/ha a.i) was applied at the first sign of aphid infestation (Table 2).

Windrowing was carried out by a contractor using a commercial machine when the crop was assessed to be at the optimum stage for cutting (when approximately 25% of the seeds had changed from green to dark brown and were firm (Rankin, 1986)). Plots were harvested with a 'Wintersteiger' plot header when the seed moisture fell to 9%; this occurred between 9-12 days after windrowing (Table 2).

Yields are presented as machine dressed weights adjusted to 9% moisture. Oil contents were determined using near-infra-red reflectance (NIR) equipment on selected treatments, and oil yield was obtained by multiplying oil content by seed yield.

Financial returns were determined by taking a price of $450/t for oilseed rape, and subtracting fixed costs of growing of $319/ha (cultivation, drilling, herbicide seed, basal fertilizer and lime, one aphicide and windrowing) and variable costs for the treatments (nitrogen fertilizer and application, and harvesting and cartage).

Data are presented mainly as figures using standard errors of the mean (S.E.M.) derived from ANOVA's to indicate the general level of variation, since the splitting of the plot effect was not large, i.e. a randomised block design can be assumed in interpreting effects.

RESULTS

The trial sites had a history of cropping with cereals two years out of three before each trial. Both sites when sampled in late July for nitrogen incubation (Quin *et al.*, 1982) recorded low nitrogen levels, with Year 2 lower than Year 1 (Table 1). The seasonal conditions between years contrasted strongly. In Year 1, a very wet spring period was followed by a dry summer which resulted in a higher irrigation requirement than for Year 2 which had a dry spring period followed by a normal summer (Table 3). These contrasting conditions may have influenced total nitrogen supply to the plant between years.

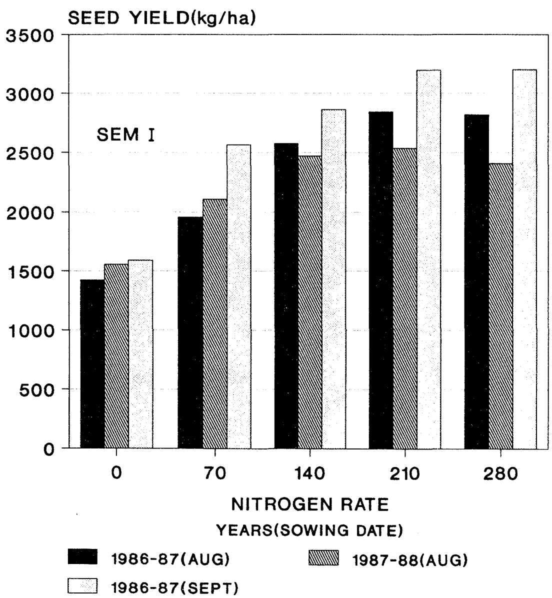

Figure 1: Effect of nitrogen rates on seed yield (SEM = standard error of the mean averaged over the two seasons).

TABLE 3: Seasonal rainfall totals (mm) from Winchmore Irrigation Research Stations Meteorological site.

	Aug-Oct	Nov-Jan	Total
Year 1	346	120	462
Year 2	136	178	314
36 yr mean	180	194	374

Seed Yield

Figure 1 shows the response of seed yield to nitrogen rates for August and September sowing in Year 1, and August sowing in Year 2. Yields without applied nitrogen were very similar between sowings at around 1500 kg/ha, despite differences in measured soil nitrogen before drilling. This low yield without applied nitrogen confirms the depleted status of these sites.

Large responses were recorded for all sowings with yields on average peaking at 2800 kg/ha with 210 kg N/ha and falling off at the highest rate of 280 kg N/ha ($P<0.01$). Yields were generally higher in Year 1 than Year 2 and peaked at a higher rate of nitrogen (210 kg/ha cf. 140 kg/ha).

Sowing in September produced consistently higher yields than in August ($P<0.01$). However greater inputs were required in terms of extra irrigations and aphicide applications (Table 2). Timing of nitrogen did not largely

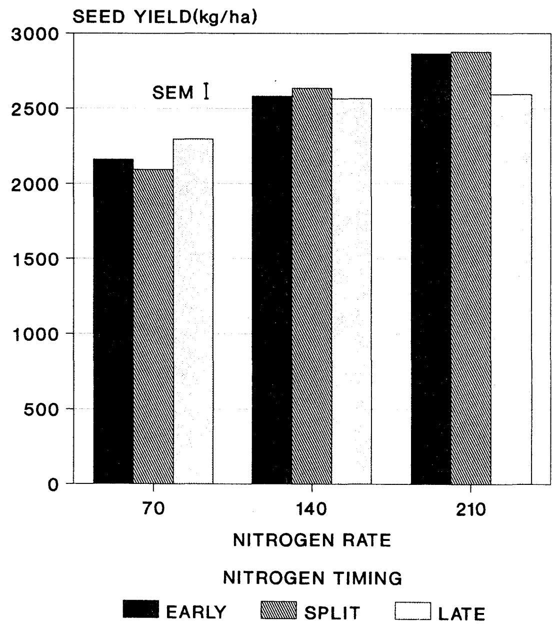

Figure 2: Effect of nitrogen rates and timing on seed yield (SEM = standard error of the mean averaged over the two seasons).

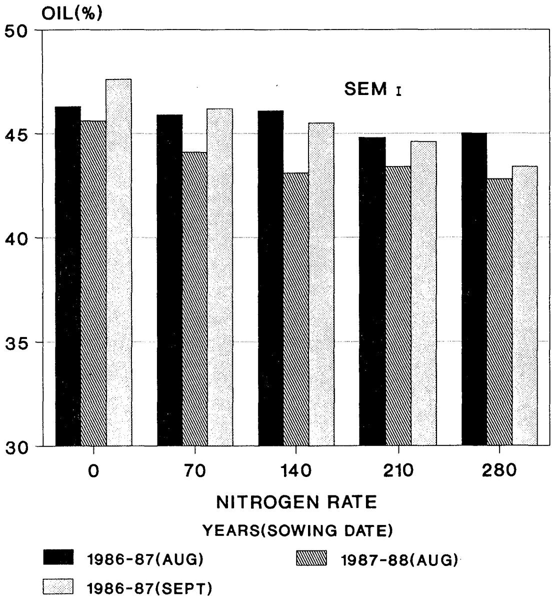

Figure 3: Effect of nitrogen rates on oil content (SEM = standard error of the mean averged over the two seasons).

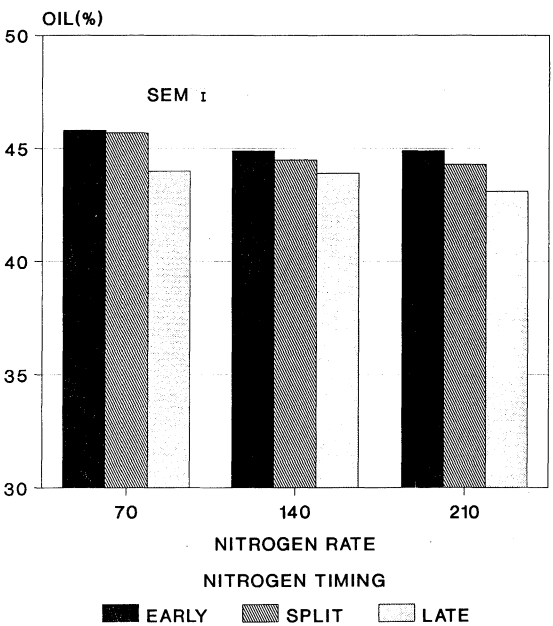

Figure 4: Effect of nitrogen rates and timing on oil content (SEM = standard error of the mean averaged over the two seasons).

influence yields (Fig. 2), though the interaction (approaching significance at 5%) indicated that at high rates of nitrogen splitting or a single early application was better than a single application late.

Forms of nitrogen did not influence yields in terms of the urea-ammonium sulphate comparison. The application of elemental sulphur alone or in combination with urea did not increase yields (Table 3).

Oil Content

The general trend over all sowing dates was a slight but consistent reduction ($P<0.01$) in oil content with increasing rates of nitrogen (Fig. 3). Delaying application of nitrogen significantly ($P<0.05$) reduced oil content (Fig. 4). Forms of nitrogen did not influence oil content neither did the addition of sulphur (Table 4).

TABLE 4: The effect of forms of Nitrogen and Sulphur on yield and oil content of Oilseed rape.

Nitrogen	Yield	Oil Content	Oil Yield	Gross Margin
	kg/ha	%	kg/ha	$/ha
Urea	2826	45.2	1309	355
Ammonium Sulphate	3004	45.7	1373	377
Urea and Sulphur*	2674	45.6	1219	234
Sulphur*	1593	47.1	753	35
*Elemental Sulphur				
LSD (5%)	416	—	190	125

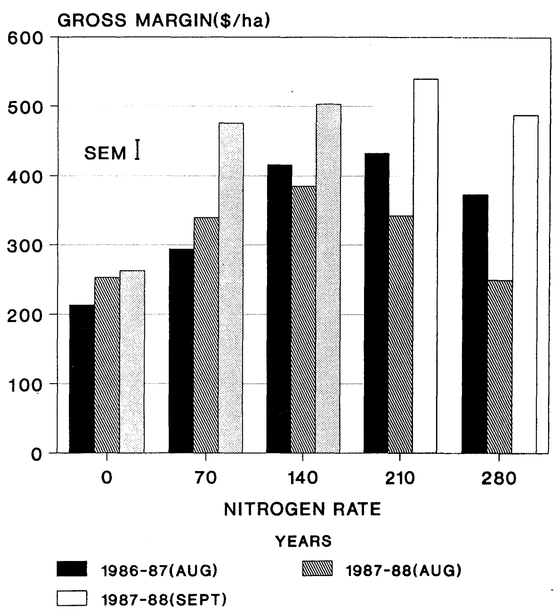

Figure 5: Effect of nitrogen rates on returns (SEM = standard error of the mean averaged over the two seasons).

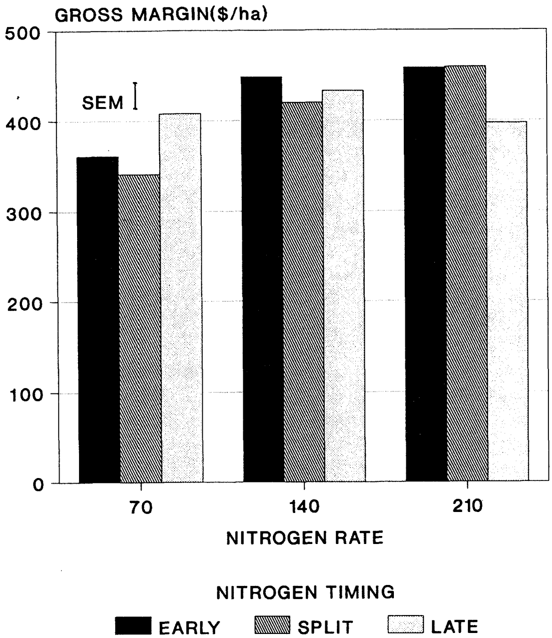

Figure 6: Effect of nitrogen rates and timing on returns (SEM = standard error of the mean averaged over the two seasons).

Oil Yield

As the effect of nitrogen in reducing oil content was small, changes in oil yields were dominated by changes in seed yields. Oil yields ranged from 1300 kg/ha for the September sowing in Year 1 to 1000 kg/ha for Year 2, and from 700 kg/ha with no nitrogen fertilizer to 1300 kg/ha with 210 kg/ha of nitrogen. Forms of nitrogen had no significant influence on oil yield. (Table 4).

Financial Returns

Gross margins are presented to demonstrate the returns relative to rate, timing and form of nitrogen. These returns did not take into account differences in irrigation or aphicide applications as firm recommendations for these cannot be made from the data in this paper. The nitrogen rate giving the highest return in Year 1 was 210 kg/ha and Year 2, 140 kg/ha (Fig. 5). As would be expected, the first 70 kg/ha was the most efficient in terms of return per kg of nitrogen applied and was best applied late, whereas early or split applications were better at the higher rates of 140 and 210 kg/ha (Fig. 6).

Ammonium sulphate and Urea gave comparable returns at 140 kg N/ha (Table 4).

DISCUSSION

Yields of 1.5 to 3.0 t/ha are normally expected from oilseed rape (Rankin, 1986). Thus the results from these trials have demonstrated that good yields can be produced on nitrogen depleted irrigated light soils with high rates of applied nitrogen.

The likely position of oilseed rape in the rotation of an intensive cropping farm is following two or more cereal crops as a break crop. For this reason it is likely to be grown on depleted sites such as those used in our comparison, and low yields are likely without the addition of nitrogen, as found in this trial and reported by other workers (Holmes and Ainsley, 1977; Osborne and Batten, 1977).

Seed yields increased with increasing nitrogen rates up to 210 kg N/ha which produced around 3200 kg/ha. The optimum nitrogen rate overall, considering both yield and economic returns, was 140 kg N/ha. This is substantially more than the 60 kg N/ha previously recommended for New Zealand conditions (Davidson, 1976; Rankin, 1986), and close to the 150 kg N/ha recommended in the United Kingdom for spring sown oilseed rape (Ward *et al.*, 1985).

The reduction in oil content with increasing rates of nitrogen seen in these results is similar to that reported by Holmes and Ainsley (1977) of up 2% for every 100 kg N/ha. Despite this reduction the large increases of seed yield to applied nitrogen, particularly for rates up to 140 kg N/ha, make this loss rather insignificant.

Timing of nitrogen had only a minor effect on yield, particularly at the optimum rate of 140 kg/ha. However, oil contents were reduced with late applications. Therefore an early (drilling) or possibly a split application (drilling, stem elongation) should be adopted. This agrees substantially with earlier findings that nitrogen should be applied at drilling (Davidson, 1976) except at high rates when split applications are recommended (Rankin, 1986). Our results suggest rates up to 140 kg/ha can be applied as a single application at drilling. However, rates above this should be split applied because of risk of germination injury.

Sowing in early August which is approximately six weeks earlier than the recommended time, resulted in a significant yield reduction. Although the September sowing yielded more, a higher irrigation and aphicide requirement was needed in this season. This was not included in the financial analysis because of the likely seasonal variation and differing cost structures between irrigation systems. Stoker and Carter (1984) evaluated irrigation responses in oilseed rape, but because of low yields and wet seasons were not able to derive precise irrigation recommendations for this crop. However, it has been shown by other workers on this soil type (Carter and Stoker, 1985; Drewitt and Muscroft-Taylor, 1978) that earlier sowing will reduce irrigation need which could be important for systems that have high running costs or for areas with water restriction and, in particular for dryland crops.

Australian work has shown that earlier sowings can give an increase in oil content (Sang *et al.*, 1986), this normally being associated with a corresponding increase in seed yield (Degenhardt and Korda., 1981; Scarisbrick *et al.*, 1981). In this comparison, earlier sowing produced a more even oil content than later sowing with a smaller decline at higher nitrogen rates. As noted above, however, seed yields were reduced by earlier sowing. This suggests that seed yield is more sensitive than oil content to changes in sowing time and that mid to late September is nearer the optimum sowing time in terms of oil production than early August.

Oilseed rape has a high demand for sulphur for protein formation and responses to applied sulphur have occurred overseas in areas which are sulphur deficient (Holmes, 1980). For this reason ammonium sulphate is often the preferred form of nitrogen fertilizer. Lismore soils are moderately deficient in sulphur but adequate levels are usually maintained with annual superphosphate topdressing (M.L. Nguyen, pers. comm.). The sites used in these trials had medium to low levels of residual sulphur (Table 1), and the crop received some basal sulphur with the application of reverted super. This would have placed the crop at a medium level in terms of sulphur supply. There was no yield response to sulphur alone or in combination with nitrogen, neither was there any difference in oil content although the treatments which contained sulphur tended to have higher oil contents. Some overseas work has shown a similar trend in that applied sulphur did not affect oil content of oilseed rape (Holmes and Ainsley, 1978; Studer, 1969), although the absence of sulphur tended to produce lower oil contents (Appelqvist, 1968).

CONCLUSIONS

- Oilseed rape has the potential to produce high yields on nitrogen depleted Lismore soils under irrigation with higher rates of applied nitrogen than previously recommended.
- The optimum economic return was obtained using a nitrogen rate of 140 kg N/ha.
- Nitrogen timing was not critical, however, best results with a single application at drilling were obtained for rates up to 140 kg N/ha. Rates above this were best split between drilling and stem extension.
- There was no significant difference in yield between urea, urea plus elemental sulphur and ammonium sulphate.

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