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INFLUENCE OF LODGING AND NITROGEN RATE ON THE YIELD AND YIELD ATTRIBUTES OF OILSEED RAPE (*BRASSICA NAPUS* L).

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Effects of lodging and nitrogen rate were studied in a field trial of oilseed rape *Brassica napus* L. Lodging decreased seed yield (16%) compared with a frame-raised crop. The yield decreased because of a significant reduction of each of the yield components coupled with a reduced plant population caused by stem breakage at the ground level. Lodging also reduced the final crop dry weight and harvest index. Seed yield also decreased from the 400 kg ha^{-1} of nitrogen application compared with 200 kg ha^{-1}. A general decrease in pod number m^{-2}, seed number pod^{-1} and seed weight caused lower yields. The use of 400 kg ha^{-1} of nitrogen changed the contribution of terminal raceme and individual branches with respect to seed yield. Seed nitrogen content and nitrogen yield increased at the 400 kg ha^{-1}, lowering both seed oil content and oil yield.

Key words: Lodging, Nitrogen rate, *B. napus* L.

Introduction

Lodging, the collapse of the crop or pods falling below the cutter level at harvest, is a serious problem in oilseed rape. The occurrence of lodging is often a seasonal phenomenon but should lodging occur early in the crop season during flowering or pod development, a high yield loss is expected [1].

Most growers in UK have applied at least 200 kg ha^{-1} of nitrogen (N) to optimize the yield of oilseed rape [2]. The effects of lodging in oilseed rape [3-5] have been reported, but its consequences were not examined on a morpho-physiological basis. In cereals, Bremner [1] and Pinthus [6] suggested that lodging was promoted by an over-supply of nitrogen because of the effects of increased nitrogen on the basal internode elongation. A similar relationship seems to exist in oilseed rape between higher rates of nitrogen and lodging. The objective of the present experiment was to evaluate the nature of yield losses caused by lodging, especially, in relation to higher rate nitrogen application. The study emphasized the morpho-physiological characteristics of individual plants at harvest.

Materials and Methods

Rapeseed variety, Bienvenu (*Brassica napus* L.) was Norsden drilled on 23 Aug. 1984 on a Boulder clay soil at the Cockle Park Experimental site of Newcastle University, England. Seven kg seeds ha^{-1} were used in 12 cm rows and the plants were singled by hand in March to restore a target population of 100 plants m^{-2}. Pre-sowing soil analysis indicated that the soil contained a high level of each of Mg, S and P, and K status was also satisfactory (Table 1). Therefore, each of N^-, P^- and K^- fertilizers was used at the rate of 50 kg ha^{-1} as basal application.

The treatment included a lodged crop that was compared with a control crop grown within a wire-frame under two levels of spring nitrogen (200 and 400 kg ha^{-1}). The basis for selection of these two treatments of nitrogen rate was to compare lodging effects with respect to the currently recommended rate (200 kg ha^{-1}) in the UK and a very high rate (400 kg ha^{-1}) which was sometimes claimed to be used by the farmers [2]. The crop was maintained upright by constructing a rigid frame around the growing crop at the early flowering stage on 9 May, 1985. Natural lodging was allowed in the other treatment. Lodging occurred on 16 June following a heavy and prolonged rainfall coinciding with the end of flowering. Nitrogen for each rate was applied in two equal splits on 28 Feb and 20 March. The factorially combined experiment was replicated four times within a randomized block design. Individual plots measured 1.8 x 8m and treatment plots were separated by a similar area of untreated crop to minimize inter-plot interference.

Crops were desiccated at maturity and harvested using a Class Compact Combine. A sub-sample of seeds off combine

TABLE 1. RESULTS OF PRE-SOWING SOIL ANALYSIS.

Sampling date	pH	ADAS* fertility index P	K	Mg	S
16.8.1984	6.3	3	2	4	4

*Note: According to ADAS (Agricultural Development and Advisory Service, UK) index, fertility level of each nutrient is marked from 0 to 5, indicating nil to a very high level of the nutrient under consideration.

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was retained for moisture, oil and nitrogen determinations, and seed yields expressed at 9% moisture content. A quadrat comprising ten rows of length 0.5m within each plot was harvested separately before combining. On the basis of sample fresh weight and plant number, a representative sub-sample of 30 plants was selected and air dried in an unheated green house. These sub-samples were later dissected on a branch by branch basis e.g. terminal raceme (TR), branch 1 (B1), branch 2 (B2) ... branch n (Bn). Pods were counted, crushed by hand and cleaned in an aspirator to separate seeds, which were weighed and counted. Data were analysed statistically and means presented with LSD or standard errors of differences of means (SED).

Results and Discussion

Summary-results of the effects of treatments as obtained after the analysis of variance (ANOVA) are shown in Table 2. It may be noted that the effects of lodging and N-rate were significant while no interaction between main treatments was apparent. This was because irrespective of N-rates, lodging occurred in all plots following a rainstorm on a particular date.

Lodging: Seed yield and yield components. Lodging caused a significant reduction of 0.75 t ha^{-1} (16.2%) in seed yield compared with the control (frame-raised crop, Table 3).

TABLE 2. SUMMARY-RESULTS OF F-STATISTICS SHOWING THE EFFECT OF TREATMENTS ON DIFFERENT PARAMETERS.

Parameter	Lodging	N-rate	Lodging x N-rate
YIELD			
Seed yield (t ha^{-1})	**	*	Ns
Seed N-content (%)	Ns	**	Ns
Seed N-uptake (kg ha^{-1})	**	Ns	Ns
Oil content (%)	Ns	**	Ns
Oil yield (t ha^{-1})	**	**	Ns
YIELD PARAMETERS			
Pod number (m^{-2})	**	Ns	Ns
Seed number pod^{-1}	**	Ns	Ns
Seed weight (mg)	**	Ns	Ns
Plant number m^{-2}	**	Ns	Ns
Crop dry weight (gm^{-2})	**	*	Ns
Harvest index (%)	**	Ns	Ns
BRANCH-WISE (PER PLANT) STUDY			
Branch number	Ns	Ns	Ns
Branch dry weight (g)	Ns	Ns	Ns
Pod number	Ns	Ns	Ns
Seed number pod^{-1}	**	**	Ns
Seed number $branch^{-1}$	**	**	Ns
Seed dry weight (g)	**	**	Ns

Ns = Not significant. * $P \leq 0.05$. ** $P \leq 0.01$.

Yield components show that seed yield loss from lodging was due to a significantly low contribution from each of the yield components. Pod number m^{-2} was reduced by 19.9%, and seed number pod^{-1} and seed weight were reduced 17.5 and 11%, respectively.

The harvest index was significantly lower in the lodged crop than that of the control because total crop dry weight and seed yield m^{-2} were significantly reduced in the lodged crop. Number of plants at harvest was significantly lower in the lodged crop; 70 plants m^{-2} compared with 83 in the control. Field observations revealed that higher plant mortality in the lodged crop was caused by stem breakage at the ground level. This might have been greatly responsible for making difference in pod number m^{-2}. Similar occurrence of stem breakage was reported by Kimber [7] and Mendham *et al.* [8], particularly, from the early lodging of oilseed rape.

Yield component analysis on a branch-by-branch basis showed that branch number, branch dry weight and pod number $plant^{-1}$ were not influenced by the lodging treatment (Table 2), since these were determined before the occurrence of lodging. Lodging strongly influenced seed number from both per pod and per branch and in turn, seed dry weight over branches (Figs. 1A, 1B and 1C). Overall lodging caused a reduction of 1.7 seeds pod^{-1}, attributable largely to the decrease in seed number per pod within the terminal raceme and higher order branches. A small amount of compensatory growth for those parameters was observed in the lower order branches of lodged crop. The decline in seed number per

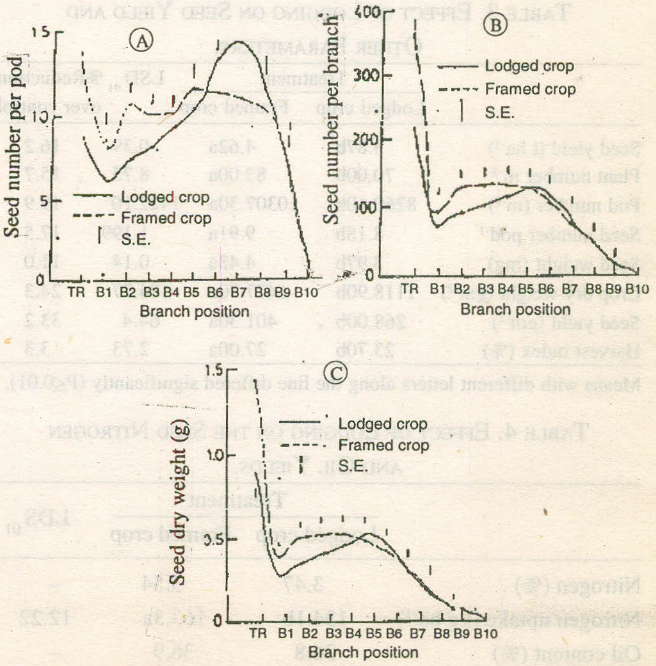

Fig. 1. Effects of lodging on the yield parameters (A, B and C) on branch by branch basis.

branch for the terminal raceme and branches 1 to 3, caused a significant reduction (25%) of seed number plant^{-1} compared with the control. Seed dry weight over branches reduced significantly with the terminal raceme and higher order branches in the lodged crop (Fig. 1C). The contribution of terminal raceme and upper four branches accounted for 61% of the seed yield plant^{-1} in the lodged crop compared to 71% in the control. These differences may be due to a higher level of pod shading in the lodged crop as that evidenced by Thomas [9] in winter wheat.

Seed nitrogen and oil yield. Lodging did not influence seed nitrogen content but lodging did cause a significantly lower (18%) seed nitrogen uptake (Table 4). Seed oil content was not influenced by lodging, although oil yield was reduced 16% due to decreased seed yield in the lodged crop.

Nitrogen Rate: Seed yield and yield components. Seed yield decreased significantly by 0.40 t ha^{-1} with increasing nitrogen from 200 to 400 kg ha^{-1} (Table 5). The high rainfall and exceptionally cloudy weather during the period from June through August may have contributed to lower yield with greater nitrogen but Scott *et al.* [10] reported that a dressing of 300 kg reduced seed yield compared to 200 kg ha^{-1}. The yield decrease from higher nitrogen level has been described by Scott *et al.* [10] as due to reduction in pod and seed number plant^{-1}. In the present experiment, increasing nitrogen rate from 200 to 400 kg ha^{-1} reduced fertile pod number m^{-2} and seed number pod^{-1} by 11 and 9%, respectively. The combined effect of yield components was also apparent from crop dry weight and seed yield m^{-2} harvest while harvest index was reduced only marginally in the higher nitrogen treatment.

A branch-wise analysis of individual plants indicates that seed number pod^{-1} was lower at the higher nitrogen rate, occurring on all branches including the terminal raceme (Fig. 2A). Similarly, a significant reduction in pod number was obtained in both the terminal raceme and primary branches 1 to 4, which greatly affected seed number plant^{-1} (Fig. 2B). The lower order branches, on the other hand, were little affected by nitrogen treatment. Seed dry weight from individual branches was consistently lower at the higher nitrogen rate for both the terminal raceme and higher order branches (Fig. 2C). The differences between treatments were significant ($P \leq 0.01$) for the terminal raceme and the first two branches

TABLE 3. EFFECT OF LODGING ON SEED YIELD AND OTHER PARAMETERS.

	Treatment		LSD$_{.01}$	%Reduction
	Lodged crop	Framed crop		over control
Seed yield (t ha^{-1})	3.87b	4.62a	0.39	16.2
Plant number m^{-2}	70.00b	83.00a	8.75	15.7
Pod number (m^{-2})	8260.10b	10307.30a	1422.10	19.9
Seed number pod^{-1}	8.18b	9.91a	1.199	17.5
Seed weight (mg)	3.97b	4.48a	0.14	11.0
Crop dry weight (gm^{-2})	1118.90b	1477.70a	184.77	24.3
Seed yield (gm^{-2})	268.00b	401.30a	64.4	33.2
Harvest index (%)	23.70b	27.00a	2.73	3.3

Means with different letters along the line differed significantly ($P \leq 0.01$).

TABLE 4. EFFECT OF LODGING ON THE SEED NITROGEN AND OIL YIELDS.

	Treatment		LDS$_{.01}$
	Lodged crop	Framed crop	
Nitrogen (%)	3.47	3.54	–
Nitrogen uptake (kg ha^{-1})	134.1b	163.3a	12.22
Oil content (%)	36.8	36.9	–
Oil yield (t ha^{-1})	1.43b	1.70a	0.14

Means with different letters along the line differed significantly ($P \leq 0.01$).

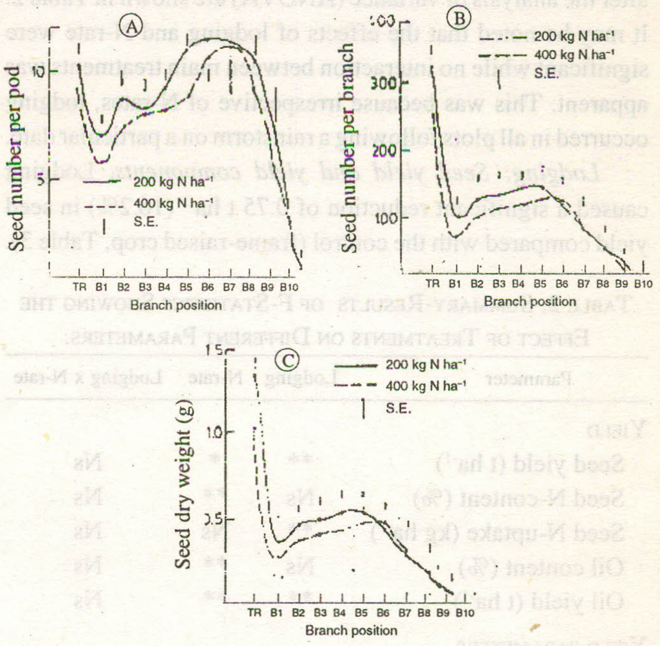

Fig. 2. Effects of nitrogen rate on the yield parameters (A, B and C) on branch by branch basis.

TABLE 5. EFFECT OF NITROGEN RATE ON SEED YIELD AND OTHER PARAMETERS.

	Nitrogen rate (kg ha^{-1})		LDS$_{.05}$
	200	400	
Seed yield (t ha^{-1})	4.44a	4.04b	0.29
Pod number (m^{-2})	9802.0	8762.0	–
Seed number per pod^{-1}	9.48	8.62	–
Seed weight (mg)	4.10	4.06	–
Crop dry weight (gm^{-2})	1389.8a	1206.9b	125.11
Seed yield (gm^{-2})	373.52a	295.77b	43.54
Harvest index (%)	26.5	24.2	–

Means with different letters along the line differed significantly ($P \leq 0.05$).

TABLE 6. EFFECT OF NITROGEN RATE ON THE SEED NITROGEN AND OIL YIELDS.

	Nitrogen rate (kg N ha^{-1})		$LSD_{.01}$
	200	400	
Nitrogen (%)	3.40b	3.62a	0.13
Nitrogen uptake (kg ha^{-1})	151.0	146.0	-
Oil (%)	37.4a	36.4b	0.46
Oil yield (t ha^{-1})	1.66a	1.47b	0.14

Means with different letters along the line differed significantly ($P \leq 0.01$).

only. The seed dry weight of the lower order branches was similar between treatments. But becuase of reduction in seed dry weight from the upper branches including terminal raceme, the lower branches (B5-B10) at the 400 kgNha^{-1} contributed 36% of the total per plant seed dry matter compared to 32% at the 200 kg ha^{-1} rate. This finding resembles to Daniels *et al.* [5] who reported that an increased rate of nitrogen decreased the contribution of terminal raceme.

Seed nitrogen and oil yield. Seed nitrogen content was signifcantly greater at the higher nitrogen rate, but seed nitrogen uptake remained similar between treatments becuase of lower seed yield at the 400 kg ha^{-1} nitrogen (Table 6). Oil content of the seed was decreased by 1.0% at the higher nitrogen level. Difference between treatments in the oil yield was also significant with 11.5% lower value at the higher nitrogen rate.

The results confirmed that lodging in oilseed rape is a damaging phenomenon reducing post-lodging dry matter production and seed yield. Therefore, attmepts should be taken to check the lodging occurrence in oilseed rape. These may conveniently be done either by changing plant type or by improving management practices. The use of plant growth retardants in oilseed rape should be considered as they have been shown to be effective in the control of plant type and lodging [11-14].

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