EFFECTS OF RATE AND TIME OF NITROGEN APPLICATION ON THE GROWTH AND YIELD OF TWO VARIETIES OILSEED RAPE (*Brassica napus* L)

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ABSTRACT

A series of field trials to examine the growth and yield of two varieties of winter oilseed rape (Pronto a hybrid and Lutin a semi-dwarf hybrid). The response to agronomic management was examined in terms of variation in nitrogen rate, nitrogen timing and seed rate. The semi-dwarf hybrid variety Lutin had a lower total biomass production and yield than the hybrid variety Pronto. In all trials Pronto produced on average 12.78 % higher yield than Lutin. The higher yield of Pronto was associated with a higher fertile pod number per m^2*, seed number per pod and thousand seed weight but lower branch number per plant. Pronto had higher biomass production, leaf area index and green area index throughout the season when compared with Lutin. The response to nitrogen rate varied considerably with the highest yield achieved at 250 kg* Nha^{-1} *in all experiments. Increasing nitrogen rate from 100 to 250 kg* Nha^{-1} *increased yield of both varieties on average by 17.91 and 20.85 % for Pronto and Lutin respectively when averaged across all nitrogen rate experiments. Increasing nitrogen rate increased branch number per plant, fertile pod number per* m^2*, seed number per pod, and harvest index during each growing season. Although there was no significant effect of nitrogen timing on the growth and/or yield of oilseed rape, the highest yield was achieved in response to a 50/50 split with the first dressing in early March and the remainder at the start of stem extension in April.*

Key Word : Brassica napus L *, Agronomic management, nitrogen application, Pronto, Lutin*

INTRODUCTION

Rapeseed is one of the major sources of vegetable oil, which comes from several Brassica species belonging to the family Cruciferae (Syn. Brassicaceae). World production of rapeseed during the last five years increased to 38.00 million metric tons, from 32.50 million metric tons, an increase of 14.5 % from the previous year. It has now become the second most important oilseed crop in the world after soybean accounting for 11 % of world production. There is now increasing interest in using rape oil for a number of industrial applications such as a renewable fuel (biodiesel), to produce lubricants and surfactants or as a feedstock for the extraction of particular fatty acids.

Brassica napus L., commonly known as oilseed rape, rapeseed or canola, is very variable including oilseed types as well as swedes, thus hybridisation might have taken place several times among different *B.rapa* and *B.oleracea* types or related species (Olsoon, 1960; Song and Osborn, *et al.*, 1992). Swede rape (*Brassica napus*) and turnip rape (*Brassica rapa* or *Brassica campestris* L) exist as annual and biennial type plants and both species contain both spring and winter types that are predominantly grown in the cool temperate regions of the Northern hemisphere such as Northern Europe, Canada and Asia.

Oilseed rape has a high requirement for nitrogen (N). Increasing the nitrogen supply increases the rate of uptake and assimilation within the plant. Spring nitrogen application supports the rapid growth which occurs with the onset of stem extension, from Growth Stage (GS 2.01). Current ADAS recommendations for spring nitrogen applications of 200 kg N ha^{-1} when the potential yield is lower than 3.5 tha^{-1} and increasing to 240 kg N ha^{-1} for sites with higher yield potentials. Holmes (1980) and Almond *et al*., (1986) have indicated that the majority of the crop's nitrogen requirement should be taken up during the period beginning in early of April and therefore, all nitrogen should be applied by this time. Frequently the crop receives nitrogen between March and early April as a single application (ADAS, 1980).

Moreover, oilseed rape is a suitable crop for preventing the leaching of nitrogen released by preceding crops, Sieling, *et al*., (1998). On sandy soils, application of nitrogen is preferable as a split dressing with half rates applied as soon as early growth occurs in the spring and the remainder by the first week of April. An application of 50 % in February and 50 % in March produced the highest yield of 4.13 t/ha from a total of 282 kg N ha^{-1} in work carried out by Dawkins (1985).

MATERIALS AND METHODS

The field experiments were conducted to examine the effect of rate and timing of nitrogen application on the growth and yield of two varieties oilseed rape during the two growing seasons. In both seasons, two rates of nitrogen 150 and 250 kg Nha^{-1} were applied as ammonium nitrate (34.5 % N) with three different timings. The levels of nitrogen timing was such that the proportion of 0.34/0.66 and 0.66/0.34 was used for the 150 kg Nha^{-1} treatment respectively and the proportion of 0.30/0.70 and 0.70/0.30 for the 250 kg Nha^{-1} respectively combined with a standard proportion of 0.50/0.50 for both nitrogen rates. The experimental design in both seasons was a split plot design with three replicates within each main plot (variety) with nitrogen rate and timing application randomised within each main plot. The nitrogen rates were split such that application occurred on March and on April.

Samples for growth analysis were taken from all plots at specific growth stages through to harvest. On each sampling occasion, unless otherwise stated 4 x 0.5 m rows were cut at ground level. From the total (4 x 0.5 m) row sample a sub sample of 10 plants was selected at random and fresh weight of the following components (stem, green leaves, flowers, buds and pods) was recorded. Yield component analysis was determined by taking 20 plant samples at random from each plot just prior to swathing and storing in an air dried unheated glass house. The following parameters were recorded for each sample: branch number, total pod number, fertile pod number, total seed number, seed number per pod, thousand seed weight and harvest index.

RESULTS

1. *Crop dry matter production*

Total crop dry weight production of both Pronto and Lutin varieties remained virtually unchanged during the period from 104 to 172 DAS and there was not significant difference between varieties at either of these dates. Data analysis in (Table 1) shown that at each sampling point from 228 to 332 DAS, total crop dry matter accumulation was significantly different between varieties with the variety Pronto produced more total crop dry weight than the variety Lutin. Leaf dry weight accounted for a major fraction of crop dry matter and increased from 172 DAS until 260 DAS. Leaf dry weight increased rapidly in the spring during stem extension and peaked around the middle of flowering. At this point the variety Pronto produced significantly more leaf material than the variety Lutin. From the middle of flowering onwards the leaf material of both varieties declined. Stem dry weight of both Pronto and Lutin varieties increased rapidly during the period from 228 to 332 DAS and there after remained largely constant. At each sampling point from 228 to 332 DAS, there were significant differences in stem dry weight between varieties. Pod dry weight of both Pronto and Lutin varieties increased rapidly during the period from 260 to 332 DAS. Following attainment of maximum leaf and stem dry weight, dry matter accumulation was restricted entirely to the pod. Data analysis in (Table 1) shown that pod dry weight was significantly different between varieties at 260 DAS. At all sampling dates pod dry weight of the variety Pronto was higher than the variety Lutin.

Table 1. Effect of variety on total crop dry weight, leaf dry weight, stem dry weight and pod dry weight during the period from 104 to 332 DAS

Days after sowing (DAS)	104 DAS	172 DAS	228 DAS	260 DAS	304 DAS	332 DAS
Total crop dry weight *(gm^{-2})*						
Lutin	155.9	192.4	566.0	922.4	1296.0	1535.6
Pronto	198.6	220.1	672.3	1165.0	1509.3	1818.9
SE	0.75	1.07	1.75	3.53	3.68	1.77
Significance	ns	ns	**	**	**	**
Leaf dry weight *(gm^{-2})*						
Lutin	119.7	144.4	209.1	278.2	53.4	6.5
Pronto	153.5	171.6	238.7	364.7	77.6	10.7
SE	0.32	1.30	1.60	2.73	0.41	0.06
Significance	ns	ns	*	*	*	**
Stem dry weight *(gm^{-2})*						
Lutin	36.2	48.0	326.6	538.9	623.8	760.3
Pronto	43.9	48.5	410.9	668.7	781.5	994.8
SE	0.69	0.36	0.12	1.30	1.53	0.89
Significance	ns	ns	**	**	**	**
Pod dry weight *(gm^{-2})*						
Lutin	-	-	-	105.2	618.8	768.7
Pronto	-	-	-	131.5	650.1	813.4
SE	-	-	-	0.89	2.74	1.86
Significance	-	-	-	**	ns	ns

Data analysis in (Table 2) founded there was a significantly different between nitrogen rates on total crop dry matter during the periods from 228 to 332 DAS with nitrogen rate of 250 kg Nha^{-1} gave the greatest response compared to 150 kg Nha^{-1}. Leaf dry weight and stem dry weight accounted for a major fraction of crop dry matter and increased from 104 DAS until 332 DAS. There was a significantly different between nitrogen rates on leaf and stem dry weight during the periods from 228 to 332 DAS. Pod dry weight also significantly different between nitrogen rates at three occasions from 260 to 332 DAS and the highest pod dry weight occurred at 250 kg Nha^{-1}. From the middle of flowering onwards the leaf material of both nitrogen rates increased. Also stem dry weight of both nitrogen rates increased rapidly during the period from 228 to 332 DAS. At each sampling point from 228 to 332 DAS, there were significant differences in leaf, stem and pod dry weight between nitrogen rates and 250 kg Nha^{-1} gave the greatest response compared to 150 kg Nha^{-1}.

Table 2. Effect of nitrogen rate on total crop dry weight, leaf dry weight, stem dry weight and pod dry weight during the period from 104 to 332 DAS

Days after sowing (DAS)	104 DAS	172 DAS	228 DAS	260 DAS	304 DAS	332 DAS
Total crop dry weight *(gm^{-2})*						
150 *kg Nha^{-1}*	172.0	202.7	509.8	962.9	1292.6	1560.1
250 *kg Nha^{-1}*	182.5	209.8	728.6	1124.5	1512.4	1794.4
SE	0.72	1.79	2.33	3.42	4.09	3.75
Significance	ns	ns	**	**	**	*
Leaf dry weight *(gm^{-2})*						
150 *kg Nha^{-1}*	134.4	155.2	200.4	297.6	49.9	6.9
250 *kg Nha^{-1}*	139.2	160.8	247.4	345.3	81.1	10.3
SE	0.54	1.11	1.50	1.47	0.52	0.05
Significance	ns	ns	*	**	**	*
Stem dry weight *(gm^{-2})*						
150 *kg Nha^{-1}*	37.9	47.5	282.9	561.6	648.8	820.3
250 *kg Nha^{-1}*	42.2	49.0	454.5	646.2	756.6	934.8
SE	0.42	0.38	2.04	2.08	2.84	2.24
Significance	ns	ns	**	**	**	**
Pod dry weight *(gm^{-2})*						
150 *kg Nha^{-1}*	-	-	-	103.7	594.2	732.8
250 *kg Nha^{-1}*	-	-	-	133.0	674.8	849.3
SE	-	-	-	2.13	2.61	2.38
Significance	-	-	-	*	**	**

There was no significant effect of nitrogen timing on total crop dry matter at all occasions, and also nitrogen timing was not significant effect on leaf, stem and pod dry weight at all sampling dates (Table 3). Data analysis of the response of the two varieties to different nitrogen rates and nitrogen timing application not interaction between them on crop dry weight production.

2. Total biomass, yield and yield components

The variety Pronto had greater total biomass and yield when compared to the variety Lutin. Total biomass production for the variety Pronto of 1818 gm^{-2} was significantly higher than the variety Lutin of 1535 gm^{-2} but Pronto having a harvest index of 0.37 was lower than the variety Lutin with a harvest index of 0.39. The yield was significantly higher for Pronto of 6.70 tha^{-1} than the variety Lutin of 5.95 tha^{-1} respectively (Table 3). There was no statistically significant difference between varieties in terms of plant number per m^2. But there was significant difference between varieties in terms of branch number per plant as Lutin is hybrid semi dwarf plant had more branches than the hybrid Pronto. The average branch number the variety Lutin was significantly higher than the variety Pronto. There was a significant difference between varieties in terms of fertile pod number per plant, fertile pod number per m^2 and total pod number per m^2 with Pronto produced more seed yield because of more seeds per pod and greater seed weight. The number of fertile pods per m^2 and total number of pods per m^2 was significantly greater for the variety Pronto compared to the variety Lutin

Table 3. Effect of variety on total biomass, yield and yield components

	Lutin	Pronto	SE	Signif
Yield *(tha^{-1})*	5.95	6.70	0.005	**
Biomass *(gm^{-2})*	1535.64	1818.85	1.77	*
Harvest index	0.39	0.37	6×10^{-4}	ns
Plant number per m^2	54	56	0.25	ns
Branch number per plant	14	11	0.08	*
Fertile pod number per plant	160.19	204.34	0.87	**
Fertile pod number per m^2	8650.26	11442.48	78.55	*
Total pod number per m^2	10749.05	14734.12	95.91	*
Seed number per pod	11.33	12.91	0.006	**
Seed number per m^2	98007.44	147722.42	954.83	*
TSW	4.47	5.25	0.004	*
Seed yield *(gm^{-2})*	438.09	775.54	5.20	*

Table 4. Effect of nitrogen rate on total biomass, yield and yield components

	150 *kg Nha^{-1}*	250 *kg Nha-1*	SE	Signif
Yield *(tha^{-1})*	5.94	6.71	0.015	**
Biomass *(gm^{-2})*	1560.08	1794.41	3.75	**
Harvest index	0.38	0.47	9×10^{-4}	ns
Plant number per m^2	53	57	0.14	**
Branch number per plant	11	13	0.09	*
Fertile pod number per plant	175.47	189.35	0.55	**
Fertile pod number per m^2	9300.01	10792.95	39.10	**
Total pod number per m^2	11839.22	13644.14	42.35	**
Seed number per pod	11.00	13.29	0.057	**
Seed number per m^2	102300.11	143438.31	603.17	**
TSW	4.81	5.02	0.013	ns
Seed yield *(gm^{-2})*	492.06	720.07	4.03	**

A general increase in yield was obtained in response to increasing levels of nitrogen applied (Table 4). There was a statistically significant difference between nitrogen rate in terms of total biomass, yield and yield components. Increasing nitrogen rate from 150 to 250 $kgNha^{-1}$ gave significantly increased the yield from 5.94 to 6.71 tha^{-1} and total biomass from 1560 to 1794 gm^{-2} and also harvest index from 0.38 to 0.47 but it was not significant. Increasing nitrogen rates significantly increased fertile pod number per plant and also total pod number per m^2. There was a significant increase in seed number per pod, seed number per m^2 and seed yield in response to fertiliser nitrogen application. Although there was a trend for increasing TSW in response to increasing nitrogen fertiliser application it was not significant.

There was no significant effect of nitrogen timing on biomass production, seed yield and yield components. But application of nitrogen timing in proportion of (50/50) % was a greater response on biomass production, yield and yield components compared to the others proportion nitrogen timing. Data analysis of the response of the two varieties to different nitrogen rates and nitrogen timing application not interaction between them on yield and yield components.

DISCUSION

Many studies have found that large differences exist between potential yield and national average yields, which indicates that a significant yield improvement could be achieved with a greater understanding of crop physiology, especially identification of the major physiological limitations to yield formation. Mendham *et al.*, (1981) and Bilsborrow and Norton (1984) identified a critical reduction in assimilate level during the post flowering phase of growth which may lead to the abortion of reproductive sinks, which in turn limits final seed yield. Clearly, from this study it may be possible to establish a greater understanding in terms of nitrogen supply and manipulation of plant density required to maximize the yield of two hybrid varieties of winter oilseed rape with contrasting growth habits.

Results from this study show that differences in plant height between Pronto and Lutin produced large differences in canopy structure, total biomass production and yield. The winter oilseed rape variety Pronto is a tall hybrid plant with a plant height at maturity 20-35 cm higher than the variety Lutin which is of semi-dwarf stature. The reduced plant height of the semi-dwarf hybrid variety Lutin resulted in a decreased total biomass, yield and leaf area index when compared to the taller variety Pronto. During the growing season Pronto produced a greater crop structure in terms of leaf area index and green area index which provided the framework for increased radiation absorption and assimilate production. Growth response of crops in the spring appears to be an important factor in determining whether the size of the crop at flowering will impose any restrictions on the final yield of the crop (Bilsborrow, 1985),

Differences in seed yield of both varieties was related to differences in yield components i.e. fertile pod number per plant, fertile pod number per m^2, seed number per pod and the individual seed weight at final harvest as shown by Mendham *et al.*, (1981) and Diepenbrock, (2000). The potential yield of the crop is determined by the photosynthetic capacity which is related to the size of the crop and leaf area at flowering (Allen and Morgan, 1975; Bilsborrow and Norton, 1984). Results during the three growing seasons showed that Pronto produced more leaf area and hence absorbed more solar radiation at flowering than Lutin. This was similar to studies by Allen and Morgan, (1972).

Increasing nitrogen rate from 150 to 250 kg Nha^{-1} increased yield of both varieties on average by 19.0 and 21.8 % for Pronto and Lutin respectively when averaged across all nitrogen rate. The maximum total biomass production of both varieties occurred at the high nitrogen rate of 250 kg Nha^{-1}. This was supported by an increase in stem, leaf and pod dry weight during the growing period. This is in agreement with Allen *et al.*, (1971), Holmes (1980), Mendham, (1981) and Morgan, (1981) that the beneficial effect of nitrogen fertiliser is manifested through its influence on crop dry weight production and harvestable seed production. Increasing nitrogen rate produced greater total pod number but a decrease in the number of fertile pods that were retained to final harvest. Scott, *et al.*, (1973) reported that application of 300 kg Nha^{-1} reduced dry matter production, leaf area and seed yield compared to an application of 200 kg Nha^{-1}.

REFERENCES

ADAS, (1985). Fertiliser recommendations, Ministry of Agriculture, Forestry and Fisheries. Reference Book No.209. p.25.

Allen, E.J., Morgan,D.G. and Ridgman, W.J., (1971). A physiological analysis of the growth of oilseed rape (*Brassica napus.* **L.**). Journal of Agriculture Science, Cambridge 77 (339-341).

Allen, E.J., and Morgan, D.G., (1972). Analysis quantitative of the effects of nitrogen on the growth, development and yield of oilseed rape (*Brassica napus.* **L.**). Journal of Agriculture Science, Cambridge 78 (315 – 324).

Almond, J.A., Dawkins, T.C.K., Done, C.J. and Askew, M.F (1984). Cultivation for winter oilseed rape (*Brassica napus*). Aspects of Applied Biology 6 (67-79)

Bilsborrow, P.E., and Norton, G., (1984). A consideration of factors affecting the yield of oilseed rape. Aspects of Applied Biology 6 (91-99).

Bilsborrow, P.E., (1985). Physiology of yield production in oilseed rape (*Brassica napus* **L.**) . PhD Thesis, University of Nottingham

Dipenbrock,W., (2000). Yield analysis of winter oilseed rape (*Brassica napus.* **L.**) : A review, Journal Field crops Research 67 (35 – 49).

Holmes, M.R.J., (1980). Nutrition of the oilseed rape crop. London. Applied Science Publisher, Ltd. London 158.

Mendham, N.J., Shipway, P.A. and Scott, R.K. (1981). (a). The effects of seed size, autumn nitrogen and plant population density on the response to delayed sowing in winter oilseed rape (*Brassica napus.* **L.**). Journal of Agriculture Science, Cambridge 96 (417 – 428).

Norton, G., Bilsborow, P.E. and Shipway, P.A. (1991). Comparative physiology of divergent types of winter oilseed ape. In: McGregor, D.I. (ed). Proceeding GCIRC Eighth International Rapeseed Congress, Saskaton, Canada, pp.578-582.

Olsson, G., (1960). Some relation between number of seeds per pod, seed size and oil content and the effects of selection for these characters in *Brassica* and *Sinapsis*. Heiditas. 46 (27-70).

Song, K., and Osborn, T.C., (991). Origins of Bassica napus : new evidence based on nuclear and cytoplasmic DNAs. In: McGregor, D.I **(ed.)** Proceeding of the Eighth International Rapeseed Congress, Saskaton, Canada, pp.3248-327.

Sieling, K., Schoroder H., and Hanus H., (1998). Mineral and slurry nitrogen effects on yield, N uptake, and apparent N-use efficiency of oilseed rape (*Brassica napus.* **L.**). Journal of Agriculture Science, Cambridge. 130 (165-172).

B. ADAPTION & PRODUCTION

No.	Session I (13.00 – 14.00) Moderator: Prof.Dr. Soedarsono	No.	Session II (14.00 – 15.00) Moderator: Prof.Dr. Soedarsono
1.	Code : B38-Isnar-O2011 Name : Arif Wibowo, Sri Wiyatiningsih Endang Triwahyu P. Title : Moler Disease Intensity in The 3 Production Centers of Shallot in Java	4.	Code : B42-Isnar-O2011 Name: Yuliani dan Yuni Sri Rahayu Title: The Growth of Leguminaceae in Calcareous Soil
2.	Code : B40-Isnar-O2011 Name : Denna Eriani Munandar Title : Effect of Mulching by Corn Biomass on Growth and Production of Corn in Drought Condition	5.	Code:B51-Isnar-O2011 Name: Ramdan Hidayat, B.W. Wijayani, Sukendah Title:The Influence of Planting Distance and Pruning on Growth and Development of Agrovoresty Sengon
3.	Code: B41-Isnar-O2011 Name: Dwi Setyorini, Zaenal Arifin Title: Effect of Fertilizer Mixed Macro *Ammonium Sulfate Nitrate* on The Growth and Production Onion in Malang	6.	Code:B52-Isnar-O2011 Name:Sigit Soeparjono Title :Effect of rate and Time of Nitrogen application on the Growth and Yield of two Varieties Oil Seed Rappe

Certificate

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