The effect of fertilizer type on brassica establishment and yield

G. D. Hayward and W. R. Scott

Department of Plant Science, P.O. Box 84, Lincoln University, Canterbury.

Abstract

An experiment was conducted to determine the optimum fertilizer type for the establishment and yield of brassicas when the seed was mixed with the fertilizer. Of the fertilizers commercially available Cropmaster 20 gave significantly lower establishment, producing under half the plant population of other fertilizers with 15% establishment of viable seed 30 days after sowing. The control gave the highest initial rates of establishment but post emergence deaths were greater. In a second experiment, the effect of broadcasting the fertilizer before drilling, and seed pelleting were investigated. Establishment was not improved by either of these treatments, with all plots averaging about 30 plants/m^2 after 30 days.

In experiment 1 lime reverted super was the highest yielding treatment and was significantly greater than Cropmaster 20, but was no better than any of the other fertilizers including the control. Phosphate based fertilizers gave lower plant population than nitrogen containing fertilizers. Individual plant weight remained unaffected and was more dependant on plant population. In experiment 2 none of the treatments had any significant effect on final yield or individual plant weight, including seed pelleting. Plots drilled with Cropmaster 20 produced significantly lower plants population than broadcast treatments. There was no difference between the fertilizers when broadcast but Lime reverted and Longlife produced significantly higher plant populations when fertilizer was drilled with the seed.

Additional key words: *plant population, nitrogen, phosphate, seed pelleting*

Introduction

Thirty years ago there was a gradual move away from the use of brassicas as supplementary feed crops for livestock, probably due to rising production costs and adoption of all grass wintering methods (Smollett, pers. comm.). The trend in the last five years however has been a move back towards brassica production, due to a combination of hard winters and poor performance of alternative wintering systems (Hook, pers. comm.).

Traditionally in dryland situations such as Canterbury and North Otago, brassicas are established using a conventional grain drill. These drills are often unable to sow brassica seed at the required rates of 0.7 - 3.0 kg/ha. To overcome this limitation in the past, seed was mixed with lime reverted superphosphate and sown through the rear fertilizer box (Lamp, 1962). Lime reverted fertilizer caused minimal damage to the seed (Inch, 1947; Wallace, 1946; Evans, 1965), even at high rates of 500 kg/ha where in South Canterbury yields of up to 71 t/ha fresh weight on light land have been produced (McLeod, 1965).

In the South Island lime reverted fertilizer has been replaced with Longlife superphosphate. Longlife, which is marketed by both Ravensdown and Southfert, contains both mono-calcium phosphate and less reactive tri-calcium phosphate, which are soluble and insoluble respectively (Braithwaite *et al.*, 1992). In addition farmers also have the choice of high analysis fertilizers.

The present study looked firstly at the influence of fertilizer type on establishment and yield of york globe turnips (*Brassica campestris*) when seed was mixed with fertilizer (experiment 1), and secondly whether improvements could be achieved by seed pelleting and/or broadcasting the fertilizer (experiment 2).

Materials and Methods

Site

The experiment was conducted on the Lincoln University research farm, Canterbury (latitude 43° 38′ S) on a Templeton silt loam of medium fertility (Table 1). The experimental site was previously in a perennial ryegrass/white clover pasture, which was ploughed in November 1992, top worked and rolled to produce a suitable seed bed with little surface rubble. During cultivation agricultural lime ($CaCO_3$) was applied at 2.5 tonnes per hectare. The least variable portion of the

Table 1. Actual and recommended soil test values for macronutrients for the experimental site. Actual results are from a M.A.F. quick test conducted on 25 February 1993. Recommended results adapted from Cornforth and Sinclair (1984).

	pH	Phosphate	Potassium	Sulphur	Magnesium	Calcium	Sodium
Actual	5.9	16	8	7	23	14	7
Recommended	5.8-6.2	20-30	7-10	10-20	5-10	N.A.	N.A.

paddock was selected and the plots were replicated in an east-west direction to reduce variability resulting from soil texture differences.

Experimental design

Experiment 1: A randomised block design was employed, with eight treatments (seven fertilizers and a control) and nine replicates giving a total of 72 plots.

Each plot measured 5 x 0.65 m, equating to an area of 3.25 m^2. Phosphate was applied at 20 kg P/ha to all treatments excluding the control. To balance varying amounts of nitrogen applied by some fertilizers, Urea (46 0 0 0) was applied four weeks after sowing to bring all plots up to a N fertiliser level of 40 kg N/ha, the amount originally supplied by the Cropmaster 20 treatment. Urea was also applied to the control. In order to assess the effect of fertilizer on establishment seed was mixed with the fertilizer (Table 2) one hour before sowing. Bare seed was sown at 800 g/ha (47 viable seeds/m^2) using a Oyjord cone seeder drill in 15 cm rows (five coulters). Bare seed had a germination percentage of 80%. Experiment 1 was sown on 28 February 1993. After sowing, Diazinon 80% E.C. insecticide was applied every second day during establishment at 350ml/200 litres of water/ha for pest control.

Table 2. Chemical composition (%) of fertilizers used in experiment 1.

Fertilizer	N	P	K	S
Longlife superphosphate	0	10	0	8
Superphosphate	0	9	0	12
Lime reverted superphosphate	0	7	0	8
Nitrogen superphosphate	12	10	10	1
Mono Ammonium phosphate (M.A.P.)	11	22	0	1
Di Ammonium phosphate (D.A.P.)	18	20	0	2
Cropmaster 20	20	10	0	13

Experiment 2: The experiment was a 5 x 2 x 2 factorial randomised block design with six replicates. Treatments were: 1. Fertilizers - a) Longlife, b) Superphosphate, c) Lime reverted superphosphate, d) Cropmaster 20 and e) Control; 2. Seed - a) Bare seed and b) Pelleted seed; and 3. Fertilizer Application - a) Drilled with seed and b) Broadcast before drilling.

The three "best" plus the "worst" fertilizer from the establishment data of experiment 1 were chosen. A sample of the same seed lot from experiment 1 was commercially pelleted, a treatment which increased seed diameter from approximately 1.5 to 3 mm and increased seed weight from 1.8 to 43 mg. Laboratory germination of viable seed was 63%, against 80% for bare seed.

Fertilizer was either broadcast on to the plots by hand before sowing or mixed with the seed before sowing as in experiment 1. In all other respects experiment 2 was conducted the same as experiment 1. Experiment 2 was sown on 12 March 1993.

Emergence

Seedling populations for both experiments were counted daily from time of first seedling emergence, approximately five days after sowing. This continued until seedling numbers stabilised, with a final count taken one month after sowing.

Yield

Experiment 1 was harvested on 13 July and experiment 2 on 20 July. All plants from a 3 m length of the middle two drill rows of each plot were harvested and washed to remove soil. After counting, tops and bulbs were weighed separately before drying to constant weight at 80°C. Emergence and yield data were analyzed using a Genstat computer programme.

Results

Experiment 1

Most plants emerged within a week of sowing but plants continued to emerge for at least two weeks, and final populations were not achieved until one month after sowing (Fig. 1). Cropmaster 20 halved the plant population and was significantly lower than all other treatments (Table 3). The control gave the highest initial rates of establishment but plant weight and yield were lower than average (Table 3).

Lime reverted superphosphate was the only treatment that was significantly higher yielding than Cropmaster 20. It was not significantly better than any other fertilizer (Table 3).

Non-nitrogen containing fertilizers produced higher plant population than Cropmaster 20, but the nitrogen containing fertilizers were no better than Cropmaster 20. On an individual basis nitrogen super was the only fertilizer to increase individual plant weight above the control. A regression of yield against plant population indicated a poor relationship, with only 28% of the variance in crop yield being accounted for by this relationship (Fig. 2). Figure 2 suggests that final yield was not greatly dependant on plant population, except in extreme examples like Cropmaster 20.

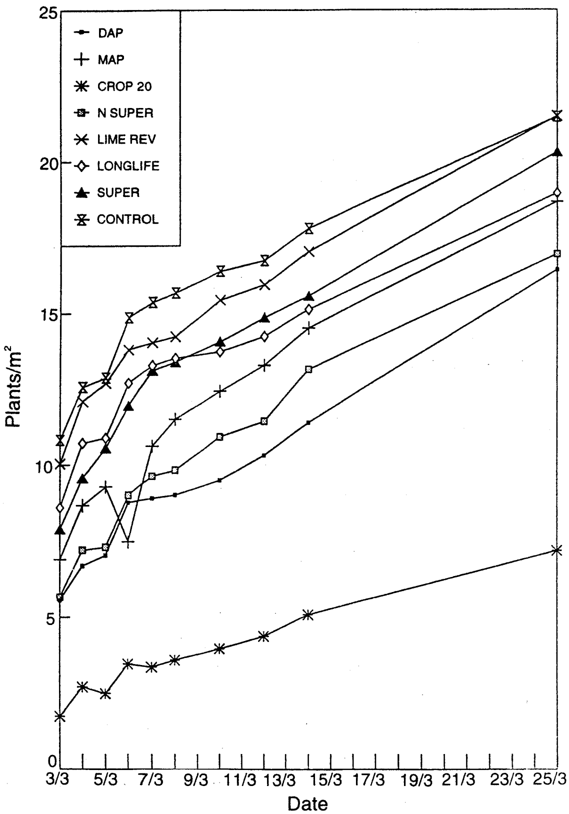

Figure 1. Brassica establishment over time for experiment 1.

Table 3. Effects of fertilizer type on final plant population, plant weight and yield for experiment 1.

Fertilizer	Plants/m^2	Wt/plant (g)	Yield (t DM/ha)
Lime reverted super	26.4 a	38 ab	10.0 a
Control	26.2 a	25 b	6.5 ab
Superphosphate	26.2 a	33 ab	8.4 ab
Longlife	28.0 a	30 ab	8.3 ab
M.A.P.	20.7 ab	38 ab	8.0 ab
Nitrogen super	18.6 ab	45 a	8.2 ab
D.A.P.	22.5 ab	39 ab	8.6 ab
Cropmaster 20	13.9 b	34 ab	4.1 b

Note: Treatments sharing the same letters are not significantly different at the 5% level.

Experiment 2

None of the treatments in experiment 2 had any significant effect on rate of establishment or final establishment, including seed pelleting (Table 4). After 30 days all plots had approximately 20 plants/m^2.

None of the treatments in experiment 2 had any effect on yield, with all plots yielding around 3.0 t DM/ha (Table 4). There were no effects of treatments on individual plant weights, which were on average 1.3 g DM/plant.

There was however a significant interaction between fertilizer type and sowing method on the plant population (Table 5). Where the fertilizer was broadcast there were no significant differences between fertilizers, including the control. Where fertilizer was drilled with the seed, Longlife and/or Lime reverted super significantly increased the plant population over the control and Cropmaster 20. Lime reverted superphosphate also had significantly more plants when the super was drilled rather than broadcast. When drilled, Cropmaster 20 produced significantly fewer plants than when the fertilizer was broadcast, and seed pelleting did not prevent this reduction.

As with experiment 1 the regression of yield against plant numbers (Fig. 3) indicated a poor relationship with only 17% of the variance among treatments accounted for. Within a fertilizer type there was also little relationship between yield and population.

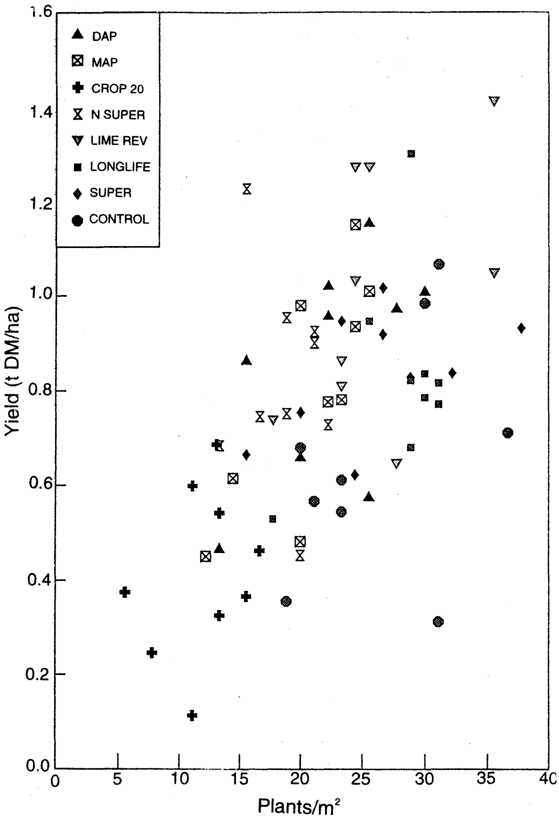

Figure 2. The relationship between yield and plant population for experiment 1.

Table 4. Effect of fertilizer type, fertilizer sowing method and seed pelleting on plant population, plant weight and yield for experiment 2.

Treatment	Plants/m^2	Wt/plant (g)	Yield t DM/ha
Control	26.6	11	2.9
Cropmaster 20	25.3	13	3.2
Superphosphate	27.0	13	3.4
Longlife	31.7	11	3.5
Lime reverted	30.5	11	3.4
Significance	n.s.	n.s.	n.s.
Fertilizer drilled	26.7	12	3.5
Fertilizer broadcast	26.7	12	3.1
Significance	n.s.	n.s.	n.s.
Seed Bare	28.7	12	3.4
Seed coated	27.7	13	3.2
Significance	n.s.	n.s.	n.s.
Sig. Interactions	* *	none	none

Table 5. The interaction of sowing method and fertilizer type on plant population for experiment 2.

Fertilizer	Plants/m^2 Drilled	Plants/m^2 Broadcast	Significance (p=0.05)
Control	26.5	26.6	n.s.
Cropmaster 20	21.5	29.1	*
Superphosphate	29.3	24.6	n.s.
Longlife	34.5	28.9	n.s.
Lime reverted	36.5	24.4	*

Note: the significance test relates to differences between drilled and broadcast treatments.

Discussion

Comparisons among fertilizer types

Lime reverted superphosphate was not significantly better than Longlife, therefore, the replacement of Lime reverted superphosphate with Longlife does not disadvantage the farmer when seed is sown in a mixture with fertilizer. When compared with Lime reverted superphosphate Longlife has several advantages, especially ease of handling due to a more granular nature (Braithwaite *et al.*, 1992). Longlife also has a higher total phosphorus content than Lime reverted (Table 2), but the citric acid solubility of this phosphate is lower (≈68%) due to about 30% of its content being reactive phosphate rock (R.P.R., Ledgard *et al.*, 1992). This R.P.R. content is slowly available, depending on factors such as soil pH and rainfall (McLaren and Cameron, 1990).

The mixing of seed with fertilizers containing nitrogen is not advisable. Cropmaster 20 contains 20% nitrogen, being 50/50 ammonium sulphate and diammonium phosphate. This product severely reduced emergence to about half that of Lime reverted or Longlife fertilizers. The most probable reason for this was through an osmotic effect, or more specifically ion toxicity or a combination of both (Francois, 1984). The ammonium sulphate present is strongly hydroscopic and will draw moisture away from the seed and prevent germination (Carter, 1967). In Experiment 1 post emergence seedling death was also observed in the Cropmaster 20 plots, presumably due to moisture being

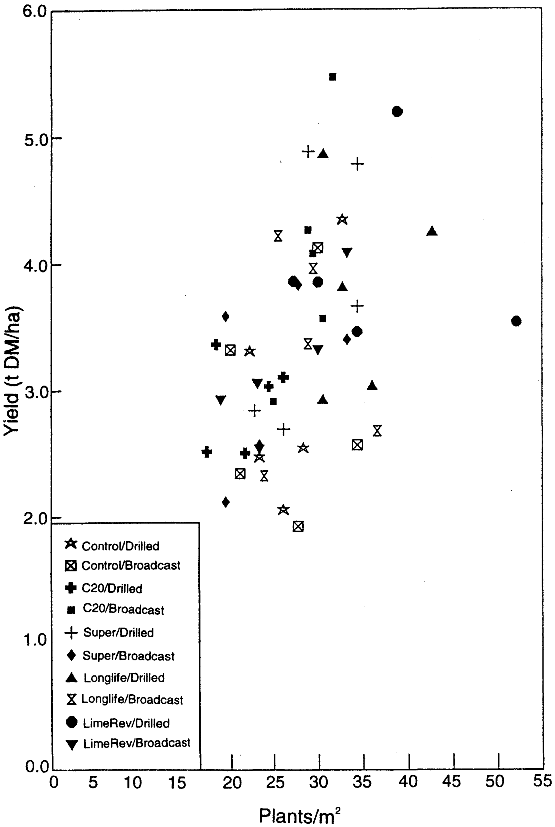

Figure 3. The relationship between yield and plants population for experiment 2.

drawn away from seedlings resulting in desiccation. Carter (1967) suggested that this osmotic effect is greatly increased with low soil moisture. The higher plant populations in Cropmaster 20 plots in experiment 2 were probably due to the fact that significant rainfall occurred on 17 March, five days after sowing. This was also the first significant rainfall experiment 1 received, nineteen days after sowing.

As ammonium sulphate and diammonium phosphate break down in soil they release ammonia gas, which is highly toxic to germinating seeds, further reducing establishment (Carter, 1967).

For Cropmaster 20 final yield was severely reduced by low plant numbers. Although there was a limited relationship between plant population and yield, the Cropmaster 20 plots were the lowest yielding and contained extremely low plant populations (Figs. 2 and 3, Table 3).

Table 6. Fertilizer costs per tonne and amount and cost required for a dressing of 20 kg phosphate/ha.

Fertilizer	Price per Tonne ($)	kg of fertilizer to give 20 kg P/ha	Cost of 20 kg P/ha ($)
Longlife (0 10 0 8); total	201	200	40.20
Longlife (0 6 0 8); cit.sol.	201	294	59.11
Superphosphate (0 9 0 12)	201	222	44.62
D.A.P. (18 20 0 2)	460	100	46.00
M.A.P. (11 22 0 1)	526	98	51.54
Cropmaster 20 (20 10 0 13)	405	200	81.00

Note: Longlife has two prices, one for total phosphate and the other for citric soluble phosphate. Lime reverted super and nitrogen super are not included as these products are no longer commercially available.

Although other nitrogen fertilizers used in these experiments did not significantly decrease germination or yield when sown with the seed of soft turnips, it must be remembered that these products cost substantially more (Table 6). The nitrogen requirement of seedlings is very low for the first few weeks of growth, around 5 kg/ha and should be easily supplied by mineralization reactions within the soil (Cameron, pers. comm.) after cultivation. It is therefore unlikely that nitrogen is required at drilling unless severe immobilisation of nitrogen is occurring through turf breakdown.

Comparisons of seed pelleting and sowing methods

Seed pelleting with a mixture of sand and clay for protection against fertilizer damage did not improve emergence, individual plant weight or yield (Table 4). There are two probable reasons. Firstly, seed pelleting reduced laboratory germination of viable seed from 80% to 63%. Secondly a mixture of clay and sand is not sufficient to hold moisture near the seed to prevent osmotic effects, or to prevent the diffusion of ammonia gas as the nitrogen fertilizer dissociates. Pelleted seed also costs more than bare seed to achieve the same sowing rate.

When seed pelleting is used for other purposes such as disease and/or insect control, e.g., damping off or springtails, then cost comes into line with conventional pest control methods.

Broadcasting fertilizer before drilling did not significantly improve final yield or individual plant weight over the seed/fertilizer mix. When Longlife and Lime reverted fertilizers were drilled, plant populations were significantly increased. Plant populations for broadcast Lime reverted and Longlife were not significantly different to that of the control. As the phosphorus and sulphur content of these fertilizers are lower it is possible that drilling improved nutrient availability close to the seed.

Broadcast Cropmaster 20 had significantly more plants than drilled treatments. This was probably due to the fact that broadcasting distributed the ammonium sulphate and diammonium phosphate crystals evenly through the soil, rather than banded with the seed (Tisdale *et al.*, 1985) resulting in less damage to the seed through osmotic effects (Carter, 1967).

As plant populations in the broadcast Cropmaster 20 plots were not significantly different from the control, it is unlikely that a phosphate and sulphur deficiency was restricting establishment.

A factor which may have limited final yield in all fertilizer treatments was the obviously uneven distribution of plants. In all other crop and pasture species the cone seeder drill has given very even plant distribution, but in the present experiment plants were very unevenly distributed for no obvious reason. If uniform plant distribution could be achieved, yields could be maximised. Clearly further work is required to determine optimum sowing density and method, and whether the trends produced in this experiment are typical across other brassica species and soil types.

Conclusions

- Longlife superphosphate is a suitable replacement for lime reverted superphosphate when seed is mixed with the fertilizer, producing similar establishment and yields. However in conditions where soil pH is high and/or rainfall is low, the R.P.R. portion of the fertilizer may remain in unavailable forms.

- On soils containing high levels of organic nitrogen, nitrogen containing fertilisers will cost more for the same rate of phosphorus/ha without improving establishment and yield.

- Cropmaster 20 should not be used when seed is mixed with the fertilizer, because establishment and yield are significantly reduced, probably due to osmotic effects and ammonia gas diffusion.

- Salt effects on establishment were minimised by significant rainfall after drilling.

- Seed pelleting did not improve establishment, individual plant weight or yields and did not protect the seed from fertilizer salt effects. Pelleting also reduced seed germination.

- Broadcasting fertilizer before drilling did not improve individual plant weight or yield but did improve plant densities in Cropmaster 20 plots, lifting them to levels similar to those of the control.

- More work is required to determine optimum plant densities and whether trends from this experiment follow across other brassica species and soil types.

Acknowledgements

We thank Ravensdown fertilizer company for their financial assistance and their agronomist Mr M. Craighead for his advice. We would also like to thank Sandy Hines for statistical analysis, Mrs E. Anderson, Miss J.A. Smollett and Mr J. Quiangfu for their technical assistance in the field.

References

Braithwaite, A.C., Eaton, A.C. and Groom, P.S. 1992. Chemical effects in commercial and laboratory mixtures of "reactive" phosphate rock and acidulated fertilizers. *Fertilizer Research* ***31***, 111-118.

Carter, O.G. 1967. The effect of chemical fertilizers on seedling establishment. *Australian Journal of Experimental Agriculture and Animal Husbandry* ***7***, 174-180.

Evans, L.H. 1965. Superphosphate reduces swede turnip germination. *Agricultural Gazette of N.S.W.* ***76***, 302

Francois, L.E. 1984. Salinity effects on germination, growth and yield of turnips. *Hortscience* ***19(1)***, 82-84.

Inch, R. 1947. Growing turnips and swedes. *New Zealand Journal of Agriculture* ***75***, 512.

Lamp, C.A. 1962. Improved turnip crop establishment. *Tasmanian Journal of Agriculture* ***33***, 42.

Ledgard, S.F., Thorrold, B.S., Sinclair, A.S., Rajan, S.S.S. and Edmeades, D.C. 1992. Summary of eleven long term trials with "longlife"phosphatic fertilizer. *Proceedings of the New Zealand Grasslands Association* ***54***, 35-40.

Mclaren, R.G. and Cameron, K.C. 1990. Soil science, an introduction to the properties and management of New Zealand Soils. Oxford University Press, Auckland. 217 pp.

Mcleod, C.C. 1965. Brassica manurial trials in South Canterbury. *New Zealand Journal of Agriculture* ***110***, 114-122.

Tisdale, S.L., Werner, L.N. and Beaton, J.D. 1985. Soil fertility and fertilizers (forth ed.). Macmillan Publishing Company, New York. 589 pp.

Wallace, J.O. 1946. Turnip and swede crops. *New Zealand Journal of Agriculture* ***73***, 215-223.