# The benefit of precision planted, pelletised swede seed when sown in cultivated soil in Canterbury and Southland

**W.W. Nichol, H. Mulcock, T. Hore, E. Butcher and B. Young**

PGG Wrightson Seeds, P.O. Box 69812, Lincoln, New Zealand

wnichol@pggwrightsonseeds.co.nz

## Abstract

A series of trials were conducted to understand if precision planting Ultrastrike® treated swede seed that had been pelletised (P) with Splitkote™ offered agronomic benefits over non-pelletised seed (U). The first series of four trials was from four sites across Southland. P significantly (LSD>0.05) increased both swede (leaf and bulb combined) dry matter (DM) yield/ha (2.1 t) and DM/plant (8 g) and bulb DM yield/ha (1.5 t) and bulb DM/plant (8 g) when compared with U swede seed sown at either 80,000 or 90,000 seeds/ha. A Canterbury site was sown on cultivated soil at Oxford, two trials were sown to compare drilling technique and sowing rate. Precision planting with P swede seed at 90,000 plants/ha (equivalent to approximately 350 g/ha untreated seed) significantly (LSD>0.05) reduced plant numbers three-fold from 27 to 9 plants/m$^2$, increased yield by 1.1 t DM/ha and individual plant weight from 34 to 108 g DM/plant relative to drilling with a Tyne drill at 1 kg/ha. Increasing the sowing rate from 80,000 to 110,000 seeds/ha with precision planting P seed did not affect DM yield/ha but significantly (P>0.05) increased plant numbers from 8 to 11 plants/m$^2$ and correspondingly individual plant weight decreased from 136 g to 96 g DM/plant. The trials have demonstrated positive effects with using Splitkote™ pelletised swede for precision sowing for crop DM yield and individual plant DM yield when sown at 90,000 seeds/ha compared with non-pelletised seed and with Tyne drilling at 1kg/ha.

***Additional keywords:*** *Brassica napus napobrassica* (swedes), plant number, dry matter yield

## Introduction

Forage swedes (*Brassica napus* ssp. *Napobrassica* L.) are an important single-graze species used for feeding livestock during the winter months when pasture growth rates are typically low, particularly in the cooler climatic regions of New Zealand (de Ruiter *et al*., 2009). A wide range of techniques are used to sow swedes from mid-November through to the end of December including those associated with cultivated soil such as broadcasting, coulter drilling, roller drilling and ridging of seed; and low or no tillage methods such as aerial over-sowing, strip-tillage and direct drilling (de Ruiter *et al*., 2009). Traditionally sowing rate for swedes is based on weight per hectare (ha) with the rate determined by the method and conditions at sowing and mediated by previous experiences with sowing rates varying from 0.5 (ridging) to over 2 kg/ha (aerial sowing) (de Ruiter *et al*., 2009).

The advent of fodder beet being used in New Zealand as a forage crop has meant the importation of specialist precision planting equipment, allowing the sowing rate to be set to a specific seed number of between 80,000 to 120,000 seeds/ha (Hussian and Field, 1991; Stocker *et al*., 2016). These specialist precision planters control plant spacing between rows and between plants in the same row. To achieve this accuracy fodder beet seed is 'pelleted' which increases seed size and uniformity. Capitalising on their investment, farmers and contractors have sown swede seed with precision planting equipment, requiring seed to be pelletised and sown at a set number of seeds/ha rather than the traditional means of weight/ha. To understand the benefits with pelletised, precision planted swedes we report on a series of field trials that covered; the number of swede seedlings that germinated when precision sown with pelletised seed compared to non-pelletised seed, sown at either 80,000 or 90,000 seeds/ha; the ideal plant population for DM yield/ha and DM/plant when seed is precision planted; and a comparison with method of swede sowing between precision planted at 90,000 seeds/ha and a Tyne drill with a sowing rate of 1 kg/ha.

## Materials and Methods

### Southland: Comparison of pelletised swede seed versus non-pelletised swede seed

To get regional distribution across Southland, four on farm trial sites were selected and sown between 12 November to 14 December 2016; at Birchwood, Ohai (45° 55' 00.4" S 167° 51' 10.8" E) on a Makarewa soil; Waimumu, Gore (46° 7' S 168° 48' E) on a Waimumu silt loam soil; Tapanui (45° 55' 06.6" S 169° 17' 06.0" E) on a Crookston silt loam and Oware; Wyndham (46° 19' 24.9 "S 168° 54' 33.4 "E) on a Wyndham silt loam. Each trial site had a comparison of non-pelletised (U) and pelletised (P) swede seed (cv. Clutha Gold) of the same swede seed line that had previously been treated with Ultrastrike®, a film-coat treatment applied to bare swede seed that offers insecticidal and fungicidal protection (PGG Wrightson Seeds, 2021). To pelletise swede seed, Seed Innovations™ manufactured and applied Splitkote™ increasing the original Ultrastrike® treated swede seed size by six-fold and to a consistent spherical uniformity. Splitkote™ pellets germinate by uptake of water through the seed coat, the seed imbibes causing the coat to split, this is followed by the development of the seed embryo and emergence from the already split seed (Seed Innovations, 2021). Across all sites, the ground was initially ploughed out of pasture and conventionally worked to a fine tilth. Contractors with precision planting capability were used to sow seed in 500 mm rows, with four rows of the P treatment and eight rows of the U treatment sown side by side per drill run (replicate), with four drill run replicates per paddock. The sowing rates were set by the contractor, at three sites 90,000 seeds/ha was sown and the only exception was the Wyndham site at 80,000 seeds/ha. The Wyndham, Tapanui and Ohai sites received 150 kg/ha of Cropzeal Boron Boost down the spout, while the Gore site did not receive any fertiliser.

Plants were counted at all the sites at approximately 14, 28 and 42 days after sowing (DAS). Number of plants/ha was calculated after counting all plants in a randomly selected 2 m long row at 0.5 m row spacing (1 $m^2$) within a replicate and repeated for each replicate giving four measurements. These same 2 m long rows were counted at each date.

Fresh matter (FM) yield (kg FM/ha) was assessed for all sites from mid to late May 2017 by hand removing all swedes in a single row, 2 m long by 0.5 m wide (1 $m^2$). Swedes removed for sampling were randomly selected within a drill run. Sampling was repeated across the four replicates giving four assessments per treatment. Leaves and bulbs were weighed separately. For each treatment, samples of leaf and bulb were collected and weighted to access DM%. Leaf samples were collected from three separate plants. Bulb samples were collected from 20 separate plants, a corer (approximately 16 mm diameter by 150 mm) was used to extract a sample, by penetrating through the bulb, on the diagonal, through the bulb starting from the side of the swede neck as described by Davey (1932). Samples for leaf and bulb were oven dried for 48 hours at 90˚C, the difference in DM verse FM was used to calculate the leaf and bulb DM%. By multiplying DM% by FM yield/m$^2$ by 10,000 m$^2$ gave the respective DM yield/ha for leaf and bulb. Swede crop total DM yield/ha is presented as the combined yield of leaf DM/ha and bulb DM/ha. Individual plant weight is calculated by dividing swede crop DM yield/ha by the number of plants/ha at harvest and converted to g DM/plant. Data were analysed using VA Meta procedure from GenStat 21st Edition (VSN International, 2020). Treatment means were compared using the Least Significant Difference (LSD) at the 0.05 significance level.

### Oxford, Canterbury trial site

Two trials, one comparing conventional and precision sowing and one comparing sowing rates, were established on a dry-land farm site at Oxford, North Canterbury (43° 16' 05.6" S 172° 12' 17.6" E) on a Pahau silt soil, with sowing on the 17 November 2018 into a conventionally prepared seed-bed with a fine, firm tilth. No starter fertiliser was applied, and 100 kg of urea/ha applied 8 weeks after sowing to the sowing rate trial only. Swede seed sown was cv. Hawkestone that had previously been treated with Ultrastrike® seed treatment. Splitkote™ seed pelleting was applied to the same seed line, to pelletise swede seed increasing the original seed size six times. Telar® herbicide, part of the Cleancrop System™ was applied at 20 g/ha across both trials. The whole trial was sprayed with 150 ml/ha Exirel® insecticide at canopy closure. Plant count and DM yield assessment were performed on the 20 May 2019 (184 DAS) for both trials. Plant count was represented as the number of plants/m$^2$ counted when hand harvested swedes were taken for yield assessment of treatments in Trial one and two.

Trial one compared Tyne drilled U swede seed with precision planted P swede seed. Seed was Tyne drilled (Taege 6m) at 1 kg/ha at a 125 mm row spacing. Precision sown swede (Amazon Ed 6 m air seeder) was sown in 500 mm rows at a calibrated drill rate of 90,000 seeds/ha. The trial was non-randomised block design, treatments were the two different sowing methods and replicates were a drill width of each method, sown side by side down the length of the paddock and repeated five times. Trial two, compared different drill calibrated sowing rates of 80,000, 90,000, 100,000, 110,000 seeds/ha sown in 500 mm rows (Amazon Ed 6 m air seeder). The trial was non-randomised block design, treatments were the four different sowing rates and replicates were a drill width of each sowing rate (lowest to highest rate), sown side by side down the length of the paddock and repeated five times.

For each five drill runs of the precision planted area in trial one and the five repeated drill runs of each different sowing rate of trial two, FM yield (kg FM/ha) was assessed by randomly selecting from each drill run, a single row 2 m long by 0.5 m wide (1 m$^2$).

All swede was hand removed, leaf and bulb were weighed separately and FM yield/m$^2$ was multiplied by 10,000 m$^2$ to give FM yield/ha. In the Tyne drilled area, a 1 m$^2$ square quadrat was randomly placed within each drill run, swede was hand harvest within the quadrat, and leaf and bulb weighted separately. For each FM yield assessment of a precision planted drill run or Tyne drilled run, leaves from three plants and a core sample (approximately 16 mm diameter by 150 mm) from 20 different bulbs were collected separately and weighed. Samples for leaf and bulb were oven dried for 48 hours at 90˚C, the difference in DM verse FM was used to calculate the leaf and bulb DM%. By multiplying DM% by FM yield/m$^2$ by 10,000 m$^2$ gave the respective DM yield/ha for leaf and bulb. Swede crop total DM yield/ha is presented as the combined yield of leaf DM/ha and bulb DM/ha. For each measurement of yield, plant numbers were recorded and presented as plants/m$^2$. Individual plant weight is calculated by dividing swede crop DM yield/ha by the number of plants/ha and converted to g DM/plant. Results were analysed by GenStat 19$^{th}$ Edition (VSN International, 2017) by ANOVA GenStat.as a non-randomised block design, with a drill run as replicates. Treatment means were compared for significant differences using the LSD at the 0.05 significance level.

## Results

### Pelletised (P) vs non-pelletised (U) seed for germination and establishment in Southland

There were no detrimental effects from using P seed versus U seed, with a significant (LSD>0.05) increase for individual plant DM weight, increased crop total yield (leaf and bulb combined) and bulb DM yield (of 8 g, 2.1 t/ha and 1.5 t/ha respectively) when averaged across all four sites (Table 1). Only the Tapanui site had a significant difference for P verse U for increased bulb and crop DM yield/ha (1.6 t and 2.4 t) (Table 1). Plant numbers/m$^2$ when P was compared with U were unaffected from sowing to 42 DAS at three individual sites but not at Wyndham which was 2 plants/m$^2$ lower. Averaged across all four sites there was a lower plant number by 1 plant/m$^2$ at harvest when P was compared with U (Table 1).

### Comparison of drilling method

Swede sown with U seed at 1 kg/ha with 125 mm row spacing is equivalent to about 257,000 seeds/ha, compared with the precision plant P swede seed at 90,000 seeds/ha. The results (Table 2) show at 184 DAS plant numbers were 90,000 plants/ha for precision planting and Tyne drill was 270,000 plants/ha which means low plant losses from sowing to harvest for both treatments. With precision planted P swede there was a significant (LSD>0.05) increase in swede crop yield/ha of approximately 1.1 t DM/ha compared to Tyne drilled, even though plant population was one third less (9 and 27 plants/m$^2$ respectively) (Table 2). Between the two sowing techniques individual plant yield was significantly ($P < 0.05$) higher for precision planted (108 g DM/plant) verse Tyne drilled (34g DM/plant) (Table 2).

### Sowing rate trial

As the number of P treated seeds sown/ha increased from 80,000 to 110,000, the number of plants at harvest correspondingly increased at the same rate (Table 3). There was no indication of plant numbers lost from the first plant count to harvest (Table 3).

**Table 1:** The effect of pelletised (P) versus non-pelletised (U) swede seed for both plant numbers established days after sowing (DAS) and plant and total dry matter (DM) yield (leaf yield DM + bulb yield DM) when precision planted at four different sites throughout Southland.

| Site | U vs P | Plant Number (per m$^2$) DAS 15 | 30 | 42 | 150+ | Bulb Yield (t DM/ha) | Total Yield (Leaf + Bulb) (t DM/ha) | Plant Yield (g DM/plant) |
|---|---|---|---|---|---|---|---|---|
| Gore | U | 9 | 8 | 7 | 10 | 12.0 | 14.6 | 152 |
| | P | 8 | 8 | 7 | 9 | 11.4 | 13.9 | 159 |
| | LSD $_{(0.05)}$ | 1.1 | 1.4 | 1.5 | 0.7 | 1.4 | 1.4 | 9 |
| Wyndham | U | 6 | 6 | 10 | 10 | 11.4 | 12.0 | 159 |
| | P | 8 | 8 | 8 | 8 | 12.0 | 13.3 | 202 |
| | LSD $_{(0.05)}$ | 1.1 | 1.4 | 1.5 | 0.7 | 1.4 | 1.6 | 43 |
| Tapanui | U | 6 | 6 | 6 | 8 | 12.3 | 14.4 | 174 |
| | P | 6 | 7 | 7 | 10 | 14.3 | 16.8 | 174 |
| | LSD $_{(0.05)}$ | 3.0 | 2.5 | 2.6 | 1.1 | 1.4 | 1.4 | 16 |
| Ohai | U | 6 | 7 | 6 | 8 | 8.5 | 11.4 | 143 |
| | P | 6 | 7 | 7 | 8 | 9.2 | 12.3 | 160 |
| | LSD $_{(0.05)}$ | 1.9 | 1.4 | 1.4 | 1.6 | 1.2 | 1.6 | 22 |
| Average | U | 7 | 7 | 7 | 9 | 10.8 | 13.1 | 163 |
| | P | 7 | 7 | 7 | 8 | 12.3 | 15.2 | 171 |
| | LSD $_{(0.05)}$ | 0.9 | 0.8 | 0.8 | 0.6 | 0.6 | 0.6 | 8 |

However, for the sowing rate of 90,000 and 100,000 seeds/ha the actual plants count was 1 plant/m$^2$ higher than expected (Table 3), indicating the calibration of the drill was slightly higher than expected. Increasing sowing rate from 80,000 to 110,000 plants/ha had no significant on DM yield/ha. Individual plant weight did decline (LSD>0.05) from 136 to 96 g/plant as the sowing rate increased by 30,000 seeds from 80,000 seeds/ha (Table 3).

**Table 2:** Comparison of plant number and yield of precision planted, pelletised swede seed at 90,000 seeds/ha versus non-pelletised swede seed, Tyne drilled at 1 kg/ha for plant numbers and plant and total dry matter (DM) yield (leaf yield DM + bulb yield DM).

| Method of sowing | Plant Number at Harvest (per m$^2$) | Leaf Yield (t DM/ha) | Leaf DM (%) | Bulb Yield (t DM/ha$^{/}$) | Bulb DM (%) | Total Yield (Leaf + Bulb) (t DM/ha$^{/}$) | Plant Yield (g DM/plant$^{-/}$) |
|---|---|---|---|---|---|---|---|
| Precision sown | 9 | 2.4 | 12.7 | 7.7 | 10.9 | 10.1 | 108 |
| Tyne drilled | 27 | 2.2 | 13.4 | 6.9 | 11.4 | 9.0 | 34 |
| Trial Mean | 18 | 2.3 | 13 | 7.3 | 11.1 | 9.6 | 71 |
| LSD$_{(0.05)}$ | 4.8 | 0.3 | 0.9 | 0.9 | 0.7 | 1.0 | 8 |

**Table 3:** The effect of different sowing rates of precision sown pelletised swede seed on plant numbers and plant and total dry matter (DM) yield (leaf yield DM + bulb yield DM).

| Sowing rate (Seed/ha) | Plant Number at Harvest (per m) | Leaf Yield (t DM/ha) | Leaf DM (%) | Bulb Yield (t DM/ha) | Bulb DM (%) | Total Yield (Leaf + Bulb) (t DM/ha) | Plant yield (g DM/plant) |
|---|---|---|---|---|---|---|---|
| 80,000 | 8 | 2.3 | 12.2 | 9.0 | 10.2 | 11.3 | 136 |
| 90,000 | 10 | 2.5 | 12.1 | 8.8 | 10.5 | 11.3 | 116 |
| 100,000 | 11 | 2.3 | 12.0 | 9.1 | 10.7 | 11.4 | 106 |
| 110,000 | 11 | 2.1 | 11.7 | 8.7 | 10.9 | 10.8 | 96 |
| Trial Mean | 10 | 2.3 | 12.0 | 8.9 | 10.6 | 11.2 | 113 |
| $LSD_{(0.05)}$ | 0.7 | 0.3 | 0.8 | 2.0 | 0.7 | 2.4 | 29 |

## Discussion

Precision planting is currently being used for sowing swede crops in New Zealand, particularly in the Otago/Southland region. For ease of setting up and calibration of drilling equipment farmers and contractors, started precision sowing swedes with pelletised seed that matches the size of spherical uniformity of pelletised fodder beet seed, this meant increasing swede seed weight six-fold from its original size. The perceived advantage was a more uniform emergence and reduced interplant competition but until now there was little supporting evidence on the effect pelletising had on germination and how this benefited crop yields.

### Effect of pelletising swede seed on germination

A key reservation with users of the pelletised seed was the perceived risk to seed germination versus non-pelletised. Prior to film-coat technology, lime was a primary component of the seed treatment and farmers noted that the lime-based coating had issues with germination especially in dry conditions due to lack of soil moisture to ‘melt’ the lime coating. Hayward and Scott (1999) confirmed such issues with lime-based seed pelletising reducing York Globe turnip (*Brassica campestris*) seed germination in the laboratory from 80 to 63% when seed diameter was increased from approximately 1.5 to 3 mm and seed weight from 1.8 to 43 mg. Due to the issues with lime pelletising, film-coat replaced this method of seed treatment, and in the current set of trials all swede seed had the film-coat Ultrastrike™ applied. Ultrastrike™ film-coat has a limited effect on increasing seed weight (<5 %) and applies an unspecified combination of insecticides, fungicide and molybdenum to the seed (PGG Wrightson Seeds, 2021; Salmon and Dumbleton, 2006). Previous research has shown (Salmon and Dumbleton, 2006) that Ultrastrike™ film-coat seed treatment had no impact on turnip seedling emergence relative to seed that was untreated but offers benefits associated with the components within the coat. For consistency the same line of Ultrastrike™ treated swede seed was used for the P versus U comparison, P treated seed had Splitkote™ pelletising applied on the outside of the Ultrastrike™ film-coat. The addition of Splitkote™ showed no effect on seed germination at the four Southland sites between P and U, with no significant differences in plant counts 15 days after sowing (Table 1) and increased total crop harvested by 2.1 t DM/ha (Table 1). Unlike the previous lime-based pelletising which had issues with germination (Hayward and Scott, 1999), Splitkote™ seed pelletising allows water and oxygen to penetrate the coating under variable conditions and the germination process begins while the pellet is still intact. It is the water uptake into the seed that exerts pressure to split the outer pellet treatment. The developing seedling emerges because of the pellet being already split by the imbibing seed (Seed Innovations, 2021). It is this 'splitting of the pellet' that differentiates it to pelletising with lime. Results (Tables 1, 2, 3) showed this method of pelletising had no detrimental effects on germination and potentially offers increased plant and crop yield (Table 1) relative to sowing with non-pelletised seed. Further work is required to verify the positive result observed with Splitkote™ pelletising in these current trials under a broader range of environmental conditions, especially when soil moisture levels are low.

### Sowing rate of pelletised swede

Farmers require swede crops that are high yielding, with relatively low leaf to bulb ratios and have soft bulbs for grazing livestock (de Ruiter *et al*., 2009). There is limited research on the correct sowing rates for swede crops and the effect on crop yield and individual plant weight, this likely reflects the number of ways swedes are sown and the conditions in which they are sown. In contrast, previous precision planting research with fodder beet has shown 500 mm spacing for between rows is optimum for crop yield (Hussian and Field, 1991; Stocker *et al*., 2016) and the same row spacing was used for the current precision planted sowing rate trial with P swede seed. As the sowing rate increased from 80,000 to 110,000 seeds/ha the space between plants reduced within the same row, this change had no effect on total DM yield/ha but did cause a reduction in individual DM plant yield (Table 3). Further investigation is needed but the initial results in the current trial shows 80,000-90,000 seeds/ha appears optimum for both crop yield and plant size, when sown in 500 mm rows at 225 mm plant spacings but the 90,000 seeds/ha rate would seem more appropriate to help mitigate some of the risk of plant loss due to pests and other factors. The use of 500 mm row spacing by farmers and contractors has been set by drills set up for fodder beet, looking at narrowing spacing between rows needs to be examined to see if this offers any additional benefit to swede crop yields. In the same context, the current studies used low fertiliser inputs. Clear benefits of establishing brassica crops such as swedes with banded phosphatic based fertiliser at sowing has been shown to enhance crop yield (Chakwizira *et al*., 2011). Precision planting drills often have this capability of banding fertiliser with the seed. Further research is required to understand if the yield gains observed with precision planting can be increased by capitalising on the opportunity to include fertiliser down the drill row at sowing to meet plant demand for growth should the soil be deficient for a specific nutrient.

### Comparison of sowing method

Unlike the sowing rate trial, the effect of sowing at the traditional 1 kg/ha rate through a Tyne drill in 125 mm row spacing showed that the high plant numbers relative to precision planted (27 vs 9 plants/m$^2$) reduced both crop DM yield and individual DM plant yield (Table 2). At 90,000 seeds/ha, assuming a thousand seed weight of 3.9 g means approximately 350 g/ha of seed was sown for precision planting excluding pellet weight. Thus, a three-fold reduction in sowing rate led to a three-fold increase in individual plant weight and a 12% increase in overall crop yield (Table 2). Increased individual plant weight and crop yield (Table 2) with precision sown swede crops may have important implications for feeding crops to animals. A higher yielding swede crop may increase the length of the transition phase required for stock moving from a pasture diet to one predominately of brassica crop (ruminal adaptation) (Nichol, 2007), and requires increased attention to getting daily crop allocation to grazing animals correct and the subsequent effect on dry matter intake and crop utilisation (Nichol, 2007). Incorrect allocation of dry matter especially leaf, may lead to greater risk of animal intake disorders such as nitrate poisoning (Nichol, 2007) and brassicas associated liver disease (Collett *et al*., 2014). High plant numbers due to higher sowing rates produce not only smaller plants with lower plant weight, as seen in the current study but are associated with an increased risk of 'necking', which is elongation of the neck, the precursor to early reproductive growth (Nichol, 2007). This may lead to negative outcomes associated with animal intake disorders associated with flowering crops (Collett *et al*., 2014, Nichol, 2007). Thus, the ability to maintain high crop yields, larger bulb size, and maintain or reduce leaf to bulb ratios enhances the need for more controlled seeding rates, supporting the need for precision planted swedes but consideration needs to be given to the effect this change is having on the grazing animal and its management on the crop.

## Conclusion

The study has demonstrated the value of precision planting with pelletised swede seed as an alternative to traditional methods of sowing seed that were based on weight rather than number of seeds per hectare. Precision planting has encouraged attention to detail with soil preparation at sowing, and the high degree of accuracy with space planting at 90,000 seeds/ha has reduced inter-plant competition for nutrients and moisture, leading to heavier individual plants and overall crop yield. Precision planting swedes will require more attention to husbandry practices such as weed and pest control, as significant reductions in plant number below 9 plants/$m^2$ will impact overall yield. Further research with precision planting to look at sowing rates and row and plant spacing would be valuable. Integration with other technologies such as low or no tillage, auto-steer on tractors, GPS tracking, precision application of both fertiliser and pesticides also needs to be explored and tested. These could reduce the area required for intensive winter grazing and reduce and improve efficiency of crop inputs. Greater adoption of precision planting with low tillage or direct drill systems could lead to improve crop utilisation and less soil damage by grazing stock.

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