| Office Use Only | |
|---|---|
| Project Code | |
| Project Type | |

# FINAL REPORT 2022

| PROJECT CODE | NSS117 |
|---|---|
| **PROJECT TITLE** (10 words maximum) | |
| Uniform seed distribution along the row to increase yields and reduce seed costs. | |

| **PROJECT DURATION**<br>*These dates **must** be the same as those stated in the Funding Agreement.* | |
|---|---|
| **Project start date** | **20/04/2018** |
| **Project end date** | **10/12/2021** |

| **PROJECT SUPERVISOR CONTACT DETAILS** *(responsible for the overall project)* | | |
|---|---|---|
| **Title:** | **First Name:** | **Surname:** |
| | Stefan | Schmitt |
| **Organisation:** | **Northern Sustainable Sandhills Inc (Northern Sustainable Soils)** | |

**PROJECT REPORT:** *Please provide a clear description for each of the following:*

**Executive Summary** (200 words maximum)

*A few paragraphs covering what was discovered, written in a manner that is easily understood and relevant to SA growers. A number of key dot points should be included which can be used in SAGIT communication programs.*


This project demonstrated that precision seeding technology could be adapted to plant winter pulse and oilseed crops such as canola, lentils and chickpeas. Spatial uniformity of seed placement was improved on average by 72% with the precision planter, however, this did not significantly improve grain yield compared with the cone seeder in the three seasons studied. There was also no indication that improving spatial uniformity by 72% would allow yield to be maximised at lower seeding rates.

There are practical limitations to using this technology at present such as opener type (double disc precision planter only option available at the moment), implication of vibration from stones or uneven surfaces impacting singulation, cost of the technology and expertise required to use the technology.

These implications were apparent in this project as we failed to achieve perfect spatial distribution of seed due to a multitude of factors stated above along with poor pre emergent chemical safety, and seed plates not perfectly matched to seed shape or size. It is plausible still that improved spatial distribution greater than 72% above what we are currently achieving with airseeders may improve crop yield or allow yield to be maximized at lower seeding rates.


**Project objectives**

*A concise statement of the aims of the project in outcome terms should be provided.*

The project aim was to evaluate the benefits of improving the spatial uniformity of seed distribution on the grain yield of chickpeas, canola and lentils. In this project, a precision seeder was used, which has the capacity to accurately plant a single seed at a time, this was compared with a cone seeder. A cone seeder best replicates the random distribution achieved by commercial airseeders. It was hypothesized that improvements to the spatial uniformity of seeds placement could result in yield being maximised at lower seeding rates. It was also hypothesized that uniform seed distribution may increase yield through reduced interplant competition, improved canopy architecture and spatial use of soil resources. As a result precision seeding equipment could improve the overall profitability of high value pulse and oilseed crops.

The study compared the two seed metering methods (labelled 'precision' and 'cone' seeder) over three years of field trials, with two years conducted at Port Broughton and one year conducted at Mallala in South Australia. The impact of metering method on interplant spacing uniformity, crop establishment and grain yield was measured over the study period. Statistical analysis was conducted with result reported further on in the technical section of this report.

## Overall Performance

*A concise statement indicating the extent to which the project objectives were achieved, a list of personnel who participated in the Research Project including co-operators, and any difficulties encountered and the reasons for these difficulties.*

Over the three-year project period field trials were successfully carried out in three years for lentils and canola and in two years for chickpeas. Data collected throughout the project was adequate enough to carry out statistical analysis to test the two hypothesis outlined in the project objective.

Whilst the impact to crop yield of precision seed metering compared to non-precision seed metering was tested successfully. It should be noted that perfect plant spacing was not achieved. A range of factors such as, seed plates not being perfectly matched to seed size each year, vibration and poor conditions for germination contributed to the undershooting of this goal. It is therefore prudent to remember when considering the results of this research that spatial distribution was improved by 72% on average and was not perfect.

I would like to thank participating farmer Richard Konzag from Mallala for hosting the 2020 trial site at Mallala. Richard was a fantastic resource with a wealth of knowledge on disc seeding. I would also like to thank Jack Desbiolle from Uni SA. Jack is an expert in seeding and tillage systems and provided highly valued advice during the project. I would also like to thank Allan Mayfield the former SAGIT scientific officer who was a great support of this project and provided fantastic mentoring and support throughout.

Numerous challenges were experienced conducting this work. Below I have outlined in dot point format challenges experienced throughout the life of the project and adaptations that were made.

**Year 1** - Using two seeders with different opener types was a cause of systematic error, which reduced the statistical validity of results. It was a challenge to find a flat site free of existing press wheel furrows that could potentially cause vibration when sowing and impede seed singulation. A site was leveled using a tandem disc. This worked well to level the ground, however, residue was unevenly spread on the soil surface. As a result this caused variation in plant establishment within and between plots.

**Year 2** - The precision seeder was modified to allow both means of seed distribution to be tested using the one type of opener (double disc). The method of fertilizer delivery was altered to liquid delivery allowing N & P to be applied in furrow. In year one fertilizer was hand spread prior to sowing, this was identified as not representative of district practice. Unfortunately it was impossible to alter the planter to apply granular fertilizer in furrow which best represents district practice. Liquid in furrow was therefore settled upon as a compromise. Larger seed size and more evenly sized canola were sourced to improve singulation. Issues arose with achieving adequate pre emergent chemical safety with the double disc opener in lentils. Unfortunately there were differences in the crop safety achieved between cone metered plots verse precision-metered plots due to differences in sowing speed between the two treatment types.

**Year 3** - The site was relocated to Mallala to a long-term disc users farm to avoid issues experienced with leveling. The soil type at this site was heavier textured when compared to the sands at Port Broughton, hence achieving adequate planting depth was a challenge. It was found that the precision planter did not have enough weight to plant below 1.5 cms on this soil type. As a result the establishment of chickpeas was impacted due to the shallow sowing. It was decided to scrap the chickpea trial in this season due to late and uneven germination of seeds.

**Year 4** – Repeat of chickpea failure in 2020 occurred – the seeding tractor was modified so hydraulic down force could be applied to the planter. It was hoped that with this feature the planter could penetrate the soil deeper. A trial site was selected near Freeling on heavy red clay on a flat fallow paddock. Again even with hydraulic down force the planter failed to plant chickpeas at depth as a result germination was patchy in two out of three replications. This trial unfortunately was not taken through to harvest as a result.

**KEY PERFORMANCE INDICATORS (KPI)**

*Please indicate whether KPIs were achieved. The KPIs **must** be the same as those stated in the Application for Funding and a brief explanation provided as to how they were achieved or why they were not achieved.*

| KPI | Achieved | If not achieved, please state reason. |
|---|---|---|
| 2018 Establish a replicated trial at NSS Bute trial site evaluating conventional tine seeding at low, medium, high sowing rates against lentils chickpeas and canola singulated at three different spacings. | Yes ☒ No ☐ | |
| Evaluate results from 2017, Interim report submitted. | Yes ☒ No ☐ | |
| Establish two trial sites evaluating seed spacings in two different soil types dune & swale. | Yes ☒ No ☐ | |
| Establish guidelines on application of this technology across multiple soil types. Submit Interim report. | Yes ☒ No ☐ | |
| Establish trial at two sites at NSS Bute trial site one in clay swallow and one on a sand hill. | Yes ☒ No ☐ | |
| Write up report, release report of the suitability of precision seeders to Mid North Soils. | Yes ☒ No ☐ | Report to be released with 2021 NSS annual results booklet. |
| Release final report to SAGIT. | Yes ☒ No ☐ | |
| | Yes ☐ No ☐ | |

**TECHNICAL INFORMATION** (Not to exceed **three** pages)
*Provide sufficient data and short clear statements of outcomes.*

RCBD small plot field trials were conducted over three seasons, two at Port Broughton (PB 2018 & 2019) and one at Mallala in 2020. Chickpeas, lentils and canola were sown at four different densities (Table 1) using two different seed metering methods, cone distribution (cone seeder) and precision planter. The precision planter was custom built by SpotonAg in Victoria (pictures of planter attached in appendix 1). In season one, seeding rate treatments were replicated three times, this was increased to five and six replications in years two and three to improve the statistical power of the experiment. Note in season two only three replicates in the canola were included in statistical analysis due to issues with the planter.

The precision planting seeder used vacuum seed metering 'v Set' meters manufactured by Precision Planting mounted on double disc row units. Seed metering was monitored using a seed senses 20/20 with optical seed counter on each row. In year one, two separate seeders were used including a cone seeder with tyne openers and the SpotonAg precision planter with double disc openers. Difference in opener type was recognized as a weakness within the experimental design in year one. Unfortunately there was insufficient time to engineer a solution to over come this prior to seeding. As a result, differences in early vigor were observed between the two seeder types in year one. This was attributed to the cone seeder having a better press wheel design and more defined furrow enabling it to make use of patchy opening rains in this season. After this season, a local engineer was engaged to modify the precision planter to allow both cone seeding and precision seeding.

Over the three seasons the same trial assessment protocol was used including measurements:

- Plant spacing on 2 x 3m rows per plot
- Interplant spacings between 30 plants by two rows per plot
- Grain yield

The uniformity of plant spacing by the two seed metering methods was calculated using the Uniformity coefficient 'Cu'. The mathematics behind this can be viewed below. The closer this number is to 100 the more evenly spaced plants are in a plot with perfectly uniform spacing achieving Cu equal to 100. Statistical analysis of all results were carried out using R.

**Uniformity coefficient: $C_u$

$$= \left(1 - \frac{\text{Av. }|\text{deviation}|}{\text{mean spacing}}\right) \times 100$$

**Table 1.** Target plant densities used for each seeder type.

| Crop Type | Density 1 (100%) | Density 2 (-12.5%) | Density 3 (-25%) | Density 4 (-50%) |
|---|---|---|---|---|
| Canola | 45 | 35 | 25 | 15 (-66%)** |
| Chickpeas | 30 | 26 | 22 | 15 |
| Lentils | 120 | 105 | 90 | 60 |

**Density 4 in canola less than 50% to explore super low density planting.

**Table 2.** Effects of conventional and precision seeding on crop establishment, the uniformity of plant spacing and grain yield in (t/ha) of lentils over three years. The significance of the difference between the precision planter and the conventional cone seeder is indicated *** -P<0.001; **-P<0.001; -P<0.05; No (*) = not significant**.**

**Note 2019 results should be treated with caution as pre emergent chemical crop safety in precision seeded plots was reduced compared to cone seeded plots due to a difference in sowing speed. As a result plant establishment was significantly reduced in precision planted plots.**

| Lentils | **Cone Seeder** | | | **Precision Planting** | | |
|---|---|---|---|---|---|---|
| | Crop establishment % | Uniformity coefficient: Cu | Grain yield (t/ha) | Crop establishment % | Uniformity coefficient: Cu | Grain yield (t/ha) |
| PB 2018 | 117 | 32 | 0.97 | 99 | 51*** | 0.91 |
| PB 2019 | 88*** | 27 | 2.01** | 55 | 43*** | 1.84 |
| Ma 2020 | 76 | 27 | 3.50 | 78 | 47*** | 3.52 |

In 2018 and 2020 there was no significant difference in the grain yield or crop establishment of lentils sown with the cone seeder or precision planter. In 2019 the yield of the cone seeder was significantly higher than that of the precision seeder, however this results should be treated with caution as per statement in table label. Over the three years the uniformity of interplant spacing was significantly better in precision planted treatments (Table 2).

**Table 3**. The effects of conventional and precision seeding on crop establishment, the uniformity of plant spacing and grain yield in (t/ha) of chickpeas over two years. The significance of the difference between the precision planter and the conventional cone seeder is indicated *** -P<0.001; **-P<0.001; **-P<0.05; No (*)**= not significant.

| Chickpeas | **Cone Seeder** | | | **Precision Planting** | | |
|---|---|---|---|---|---|---|
| | Crop establishment % | Uniformity coefficient: Cu | Grain yield (t/ha) | Crop establishment % | Uniformity coefficient: Cu | Grain yield (t/ha) |
| PB 2018 | 108 | 38 | 1.13 | 109 | 60* | 1.2 |
| PB 2019 | 88 | 28 | 2.06 | 77 | 51*** | 2.01 |
| Ma 2020 | - | - | - | - | - | - |

In 2018 and 2019 there was no significant difference in the crop establishment or grain yield between the cone seeder or precision planter. However, there was a significant improvement in the uniformity of interplant spacing over the two seasons in precision planted treatments.

**Table 4.** The effects of conventional and precision seeding on crop establishment, the uniformity of plant spacing and grain yield in (t/ha) of canola over three years. The significance of the difference between the precision planter and the conventional cone seeder is indicated *** -P<0.001; **-P<0.001; **-P<0.05; No (*) = not significant.**

**Note 2018 results should be treated with caution as plant establishment was reduced in precision seeding plots in this season compared to cone seeded plots due to differences in opener type disc verse tyne. This was confounding factor was rectified with machinery modification in years 2019 and 2020.**

| Canola | Cone Seeder | | | Precision Planting | | |
|---|---|---|---|---|---|---|
| | Crop establishment % | Uniformity coefficient: Cu | Grain yield (t/ha) | Crop establishment % | Uniformity coefficient: Cu | Grain yield (t/ha) |
| PB 2018 | 77 | 27 | 1.07*** | 98 | 48*** | 0.83*** |
| PB 2019 | 65 | 28 | 2.21 | 64 | 54*** | 2.18 |
| Ma 2020 | 43 | 27 | 1.67 | 54 | 50*** | 1.68 |

In 2018 there was a significant difference between the grain yield of cone seeded plots compared with precision planted plots. This result is however confounded by the fact that opener types between the two treatments were different in this season and should be treated with caution.
In all seasons there was no significant difference in the crop establishment of precision plated plots verse cone seeded plots. In all three seasons there was a significant improvement in the uniformity of interplant spacing in precision seeded plots verse the cone seeder.

**Table 5.** Difference in average uniformity coefficient value between cone seeder and precision seeder %.

| Average Uniformity Coefficient Cu (Cone Seeder) | Average Uniformity Coefficient Cu (Precision Seeder) | Average Improvement in Uniformity Coefficient Cu of Precision over Cone Seeder |
|---|---|---|
| 29.25% | 50.5% | 72% |

Over the three years of this work the precision planter on average had a 72% higher uniformity coefficient.

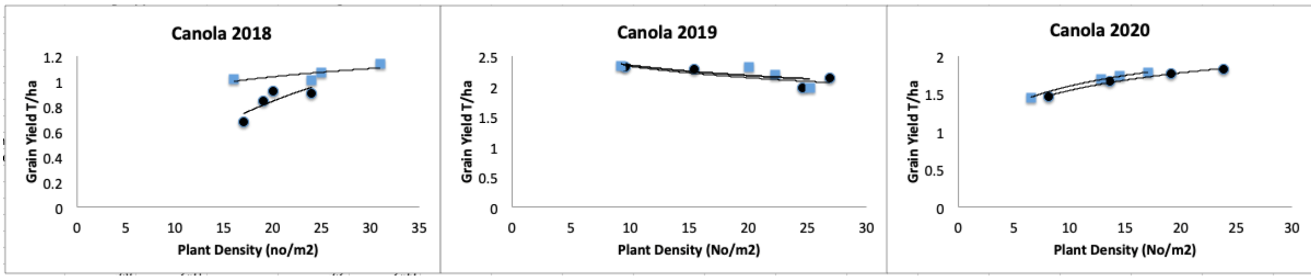


**Figure 1.** The relationship between established number of plants/m2 and the yield of canola sown with a conventional seeder (■) or a precision seeder (•) over three seasons. There was no clear trend in any season of the precision planter allowing grain yield to be maximised at lower seeding rates.

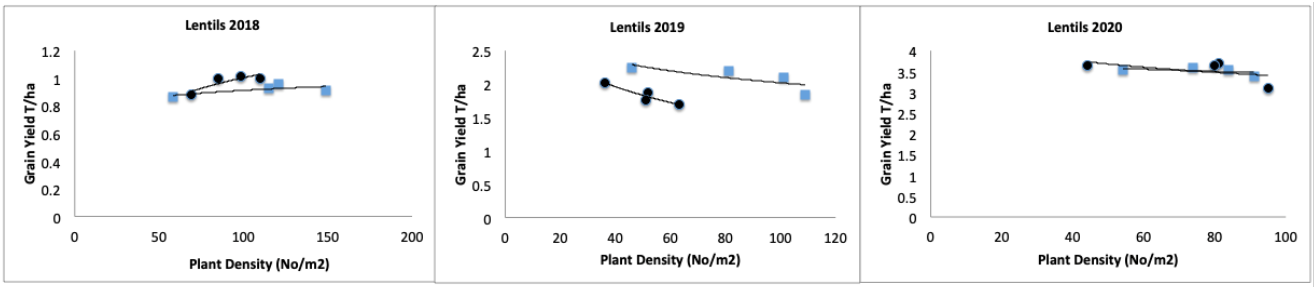


**Figure 2.** The relationship between established number of plants/m2 and the yield of lentils sown with a conventional seeder (■) or a precision seeder (•) over three seasons. There was no clear trend in any season of the precision planter allowing grain yield to be maximised at lower seeding rates.

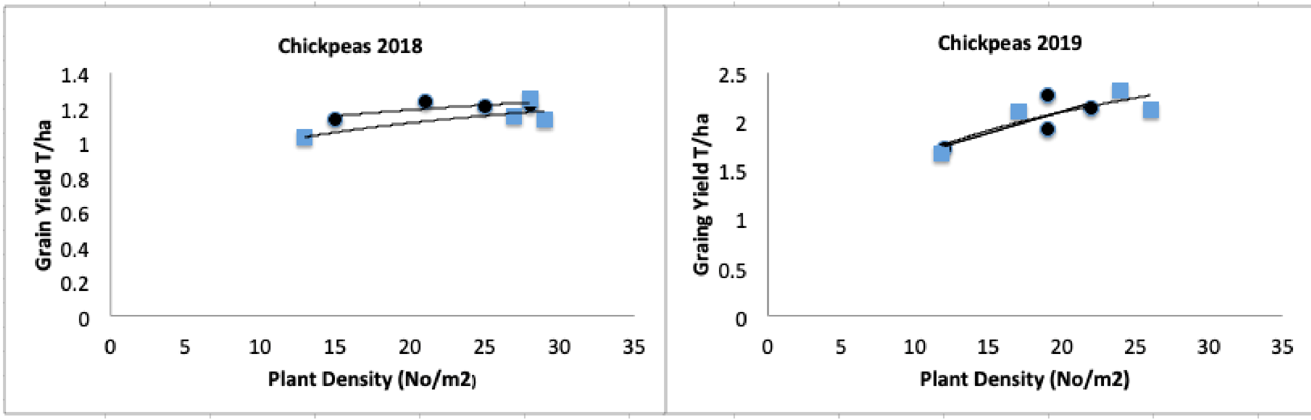


**Figure 3.** The relationship between established number of plants/m2 and the yield of chickpeas sown with a conventional seeder (■) or a precision seeder (•) over two seasons. There was no clear trend in any season of the precision planter allowing grain yield to be maximised at lower seeding rates.

## CONCLUSIONS REACHED &/OR DISCOVERIES MADE (Not to exceed one page)

*Please provide concise statement of any conclusions reached &/or discoveries made.*

This study has demonstrated that precision seeding technology can significantly improve the uniformity of interplant spacing compared to a cone seeder, which best replicated the uniformity achieved by airseeders.

An improvement in the uniformity of plant spacing in the order of 72% or more on average by the precision planter did not result in a significant yield improvement in any of the three crop types over the three seasons. There was no significant difference between the plant establishment of precision metered seed compared to the non-precision seed metered (cone seeder) when opener type was held constant. There was no indication in this study that by improving the average uniformity of plant spacing by 72% through more accurate metering could allow yield to be maximised at lower seeding rates.

Achieving perfect plant spacing with a precision seeder in a field scenario in the given crop types was found to be a challenge. There are many factors such surface evenness, seed size, type, uniformity and available seed plates that contribute to the precision seeders ability to perfectly space seed.

When static testing, highly accurate seed metering can be achieved with 90-100% singulation in lentils and chickpeas. There are many in field factors that impact how perfectly metered seed establishes, which has been demonstrated by the inability to achieve perfect spacing in these trials.

This has highlighted that in field scenarios having a buffer of extra seed / allowing for establishment failures is important to achieving desired densities. It also highlights the intricacies in establishing uniform crop stands with a precision planter at field conditions.

## INTELLECTUAL PROPERTY

*Please provide concise statement of any intellectual property generated and potential for commercialisation.*

The NSS retains the IP of data collected, however asks only the appropriate acknowledgment of the source of the data is made to be used.

## APPLICATION / COMMUNICATION OF RESULTS

*A concise statement describing activities undertaken to communicate the results of the project to the grains industry. This should include:*

- *Main findings of the project in a dot point form suitable for use in communications to farmers;*
- *A statement of potential industry impact*
- *Publications and extension articles delivered as part of the project; and,*
- *Suggested path to market for the results including barriers to adoption.*

*Note that SAGIT may directly extend information from Final reports to growers. If applicable, attach a list of published material.*

- The uniformity of plant spacing can be improved by 72% though the adoption of precision seed metering technology with the ability to singulate seed over traditional airseeder distribution.
- This study did not find that improving the uniformity of plant spacing beyond that achieved by a cone seeder increased the yield of lentils, chickpeas or canola.
- This study did not find that improving the uniformity of plant spacing's by 72% compared to airseeders allowed seeding rates to be lowered without impacting yield.
- Whilst achieving accurate seed singulation using precision seeders is achievable, achieving even and full germination under field conditions is a challenge.
- Precision planters require good paddock preparation in order to work properly. Limitations currently exist in the ability to place granular fertilizer in furrow and in choice of opener type. At present the majority of precision planter use double disc openers due to the reduced vibration inherent to discs.
- Currently available seed plated are not perfectly suited to lentils and chickpeas and may require minor modification.
- Potential industry impact, at present this work does not have a lot of impact to industry other than to show that there is not economic rationale at present to adopt precision seeding technology in lentils, chickpeas or canola in SA. With no proven results there is no need to adopt this technology at this point of time.
- This work has been extended via, radio ABC north and west, social media (NSS facebook), NSS annual results booklets to members, NSS field days and Hart field days. A final report will be included in the 2021 trial results booklet to NSS members.

## POSSIBLE FUTURE WORK

*Provide possible future directions for the research arising from the project including potential for further work and partnerships.*

The results of this study have demonstrated that there was no economic benefit from improving crop stands uniformity by 72%. It is possible however that if 'perfect plant spacing's' were achieved like originally desired that there might still be some benefit to either yield or ability to save seed.

With more time and capital, additional work could be conducted on optimizing seed metering plate design to better suit chickpeas and lentil. There is also scope to explore adapting precision seed metering to a tyne opener through a joint project with Uni SA.