# Impact of Seeding Density and Time of Sowing on Soybean Productivity in Southern NSW

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## Abstract
With the expansion of the irrigated soybean industry in southern NSW and the release of new high yielding varieties there has been a gap identified in the knowledge of specific variety agronomy required for maximizing grain yields of these varieties. Preliminary trials by NSW Department of Primary Industries at Yanco have shown significant yield increases can be made with only small changes to plant populations and time of sowing. Grain yield results from these trials grown under a furrow irrigated raised bed (2 rows/bed) system indicate there are positive yield responses with plant densities up to 35 plants/m$^2$.

### Key words
Density, maturity, lodging, plant population, yield.

## Introduction
The irrigated soybean industry in southern NSW plays an important role as a legume crop in a diverse multi seasonal irrigated cropping system. While soybean agronomy is more complex than that of cereals, it can be very responsive to good management (James et. al. 1996). With the increasing cost of inputs, in particular water and its allocation availability, it is important that growers maximise returns per mega litre (ML) of water. If variety specific soybean agronomy guidelines were developed which are easily implemented, growers could reduce input costs, and stabilise yields. By managing seeding densities, time of sowing and variety selection growers could reduce seeding costs, increase harvest index and increase harvesting efficiency through reduced crop lodging.

Current breeding objectives for the southern region in the Australian Soybean Breeding Program (GRDC CSP00157) are to produce soybean varieties suitable for human food markets that are high yielding, early maturing, with disease tolerances and good agronomic traits. Ideally, in southern NSW later sowings and earlier maturity offer greater flexibility for fitting soybean into double-cropping systems (Gaynor et.al. b. 2011).

In this paper we look at some agronomy management options such as time of sowing and plant density treatments to improve yields of current  varieties, namely Bidgee, Snowy and Djakal. A potential new variety NOO5A-80 was also included in the experiments. To enable growers to maximise yield, some variety specific agronomy practices need to be evaluated and identified.

A gap in knowledge for maximising the yield of the variety Bidgee, released in 2012 has been identified. This is due to the significant phenology differences between Bidgee and other varieties currently grown, Djakal and Snowy. Bidgee differs greatly with a significantly shorter time to physiological maturity, smaller seed size, shorter plant height and apparent photoperiod and thermal growth response. In order to maximise yields it is also important to understand the differing variety responses across seasons with different management practices.

## Materials and methods
The following trials were conducted on the NSW Department of Primary Industries Leeton Field Station. The trials were grown on a self-mulching medium clay soil, on 1.83m wide beds, with 2 rows per bed, at 90 cm row spacing. The beds were in-furrow irrigated with approximately 8 ML/ha of applied water for the entire growing season. All plots were in-furrow inoculated and all plots were sown with 125 kg/ha of grain legume fertiliser at sowing.

*Plant populations x time of sowing trial 2012/13*
A trial was conducted to test the yield response of the current varieties Bidgee, Snowy and an advanced breeding line NOO5A-80 at target densities of 10, 20, 30 and 40 plants per m$^2$. Seeding rate calculations were based on actual seed weight with measured germination and a plant establishment of 85%. The trial was repeated at 2 sowing times in the recommended sowing window for southern NSW, with the first sown on 22 November 2012 and the second on 21 December 2012. These sowing times are considered ideal for the November sowing time and late, but acceptable, for the December sowing time.

*Plant population trial 2013/14*
A further plant population trial was conducted at the Leeton Field station in 2013/14 station to test the yield response of 4 varieties Bidgee, Djakal, Snowy and NOO5A-80 over five plant densities from 10 to 50 plants per m$^2$. The trial was sown 21 November 2013.

**Results**
*Plant populations x time of sowing trial 2012/13*
Yield and lodging results from this trial indicate that the varieties tested respond differently to increases in plant density and time of sowing. The population data is presented as seeding densities because actual plant density data was not available. However, the plant populations targeted were observed to be reliable.

The first sowing date had a trial mean yield of 3.9 t/ha, an increase of 0.7 t/ha or 18% over the second time of sowing, with a trial mean yield of 3.2 t/ha. Within each variety there was some differences detected. Snowy showed significant yield responses across all densities while NOO5A-80 showed significant ($p<0.05$) yield increase at the 20, 30 and 40 plants/m$^2$ treatments. Bidgee showed no significant yield increase across all density treatments in time of sowing 1 (Figure 1). The yield difference between time of sowing 1 and 2 indicates that for a yield level of <3 t/ha, a population of 10 to 20 plants/m$^2$ is adequate from this data. To achieve grain yields >3 t/ha, plant densities from 20 to 30 plants/m$^2$ would be required.

Interestingly, increasing the sowing density with delayed sowing did not generally increase grain yield. A possible reason for this could be due to the delay in crop maturity with the cooling temperatures of autumn. The growth rates of soybeans are reduced with cool temperatures and this may combine with their in-determinant nature to limit yield potential. Further study is required to look at plant seed yield distribution at each node site and the plants pod and seed development late in the season under cool temperatures. This trial indicated that Bidgee had a relatively stable yield across the population range possibly due to its quick growth rates and phenology compared to Djakal and NOO5A-80. It is important to consider that this time of sowing affect is only measured over one season and further analysis over multiple seasons is required to identify some definitive genotype and environment interactions.

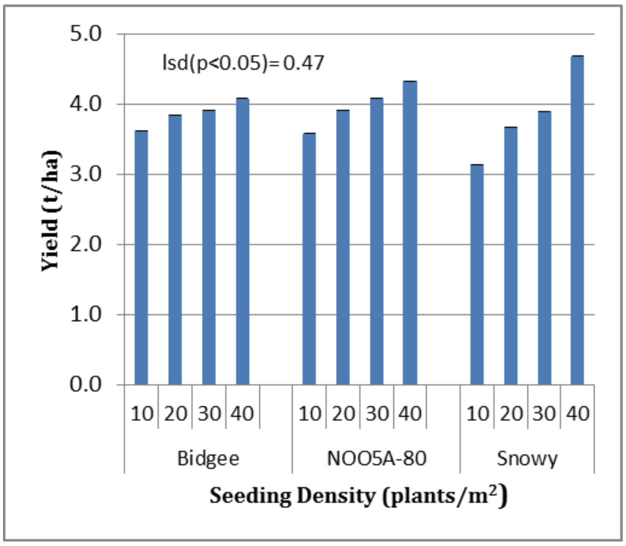


**Figure 1. Effect of seeding density on 3 varieties x 4 sowing densities. Sown at Leeton Field Station on 22 November 2012.**

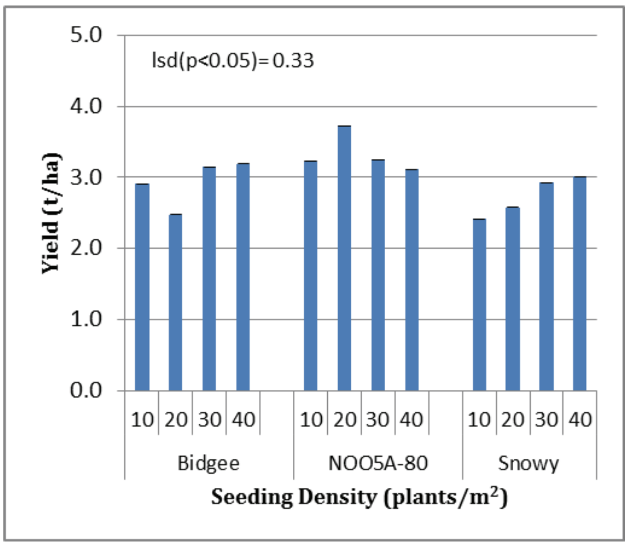


**Figure 2. Effect of seeding density on 3 varieties x 4 densities. Sown at Leeton Field Station on 21 December 2012.**

There were significant ($p<0.05$) differences measured in varieties, from the number of days to 95 % of plants reaching physiological maturity (P95) between sowing time 1 and 2. Due to an apparent thermal response Bidgee and Snowy had large reductions in their days to P95 of 16 and 11 days respectively. The delayed sowing had a lesser effect on Djakal and NOO5A-80 of 4 and 5 days. Under the same environment and seasonal conditions, the length of the growing period of Bidgee and Snowy appear to be strongly affected by thermal time and photoperiod than that of Djakal and NOO5A-80. Djakal and NOO5A-80 have a more stable length of growing season and are less affected by changes in time of sowing and seasonal conditions. The length of the growing season of Djakal & NOO5A-80 appears to be relatively stable irrespective of date of sowing. Bidgee and Snowy tend to mature at similar times irrespective of time of sowing. This characteristic leads to less biomass and a lower yield potential.

*Plant population trial 2013/14*

Five plant populations were sown within each variety and plant populations were measured for each treatment and can be seen below in Table 1. Some significant yield and lodging interactions were observed in this trial. Averaged across all varieties, the Treatment 1 was 0.85 t/ha (24%) lower yielding than the average yield of treatments 2 to 5. There was no significant ($p<0.05$) yield difference between sowing density treatments 2-5 averaged across all varieties (Figure 3).

**Table 1. Seeding Densities. Trial sown at Leeton Field Station on 21 November 2013.**

| | Seeding Density (plants/m$^2$) | | | | |
|---|---|---|---|---|---|
| **Variety** | **Treatment 1** | **Treatment 2** | **Treatment 3** | **Treatment 4** | **Treatment 5** |
| Bidgee | 8 | 21 | 25 | 33 | 49 |
| Djakal | 6 | 13 | 21 | 29 | 32 |
| NOOSA-80 | 8 | 19 | 26 | 37 | 43 |
| Snowy | 8 | 23 | 30 | 36 | 44 |
| **Mean** | **8** | **19** | **25** | **34** | **42** |

Snowy scored significantly higher than all other varieties for plant lodging across all densities (Figure 4). Snowy has a known strong genetic link to plant lodging which could explain the majority of differences observed in this experiment. Data from previous work indicates the degree of lodging with Snowy varies depending on season and rainfall. It has been observed that high rainfall at peak total dry matter can contribute to severe lodging. There was also a significant ($p<0.05$) increase in lodging with all increases in sowing populations.

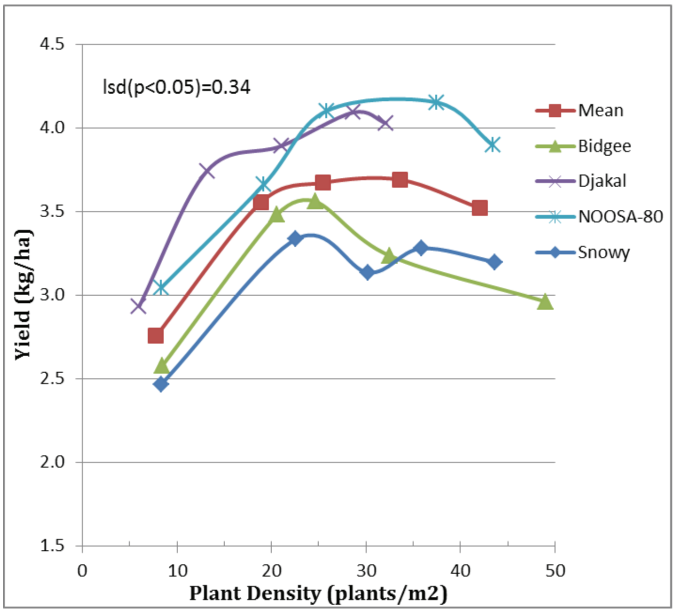


**Figure 3. Grain yield of 4 varieties at 5 densities. Trial sown at Leeton Field Station on 21 November 2013.**

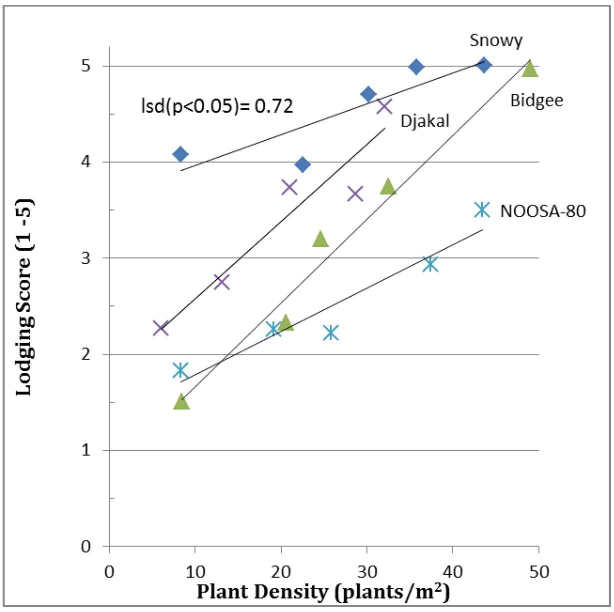


**Figure 4. Variety lodging score (1 = erect, 5 = flat) of 4 varieties at 5 target plant densities. Trial sown at Leeton Field Station on 21 November 2013.**

While all varieties recorded a significant difference in seed size across varieties there was also a significant reduction in seed size across varieties at the lowest population Treatment 1 of 4% (data not presented). This reduction in seed size may have contributed to the yield decrease of this treatment. No significant effect of population on seed protein level was observed.

There was a significant effect of population on crop duration from sowing to 95% physiological maturity (P95). There was an average increase of 3.5 days for densities greater than 35 plants/$m^2$. This is likely to be due to the delay in maturity caused by increased biomass and lodging and hence the longer time to reach physiological maturity under an irrigated system. Frequent observations from previous trials have shown this affect. The main consequence of this is that harvest maturity will be delayed, as a result of the plant and seed take longer to dry down.

**Discussion**

Grain yield results from these trials grown under a furrow irrigated raised bed (2 rows/bed) system indicate that increasing soybean sowing rates above 35 plants/$m^2$ show no yield advantage. It will not only result in a lower gross margin due to increased seed costs, but also increased harvest difficulties as a result of significant increases in plant lodging.

It would appear from these trials that in southern NSW a target plant density of 35 plants/$m^2$ is adequate for maximising yields whilst minimising the risks of increased lodging from higher sowing rates above this level. Whilst Snowy shows increases in grain yield with increases in population, there are some considerable disadvantages, including increased lodging, delayed harvest and decreased harvest efficiency. Plant breeding programs should continue to invest in developing lodging resistant cultivars.

The genotype NOO5A-80 performed strongly in these experiments and shows great promise with good yields, a stable growing season length and lower lodging potential.

It would appear from this preliminary work that current varieties respond differently from delayed sowing to days to physiological maturity (P95). Bidgee in particular with its characteristic quick maturity exhibits a likely temperature related physiological response which reduces the total days of crop duration in a delayed sowing situation. This response could reduce the total amount of biomass produced and therefore reduce the total yield potential of the crop. Further research is required to identify the effects of this genotype by environment response so as to make more specific agronomy guidelines to maximise yields with current varieties.

Further research is currently underway in the GRDC project (DAN00192) Southern NSW Soybean Agronomy to investigate strategies required to maximise the grain yields of new and existing soybean varieties in southern NSW and northern Victoria.

**References**

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