Office Use Only	
Project Code	
Project Type	

FINAL REPORT 2024

PROJECT CODE	SAR-01222
PROJECT TITLE	
Ground truthing wheat and barley flowering time in the Mid North and Mallee using the Mesonet	

PROJECT DURATION						
Project start date	**1/04/2022**					
Project end date	**1/02/2024**					
SAGIT Funding	Year 1		(year)	$	(year)	$

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PROJECT REPORT:

Executive Summary

This project aimed to characterise the environmental differences across the Mid North and SA Mallee regions and the subsequent effects on sowing time and variety selections for cereals. It aimed to use the Mesonet weather station network to ground truth wheat and barley flowering time compared to those obtained through Agricultural Production Systems sIMulator (APSIM). Key findings for the project showed that observed flowering dates can be simulated using APSIM, observed Mesonet derived weather data or interpolated patch point data (PPD) obtained through SILO LongPaddock (https://www.longpaddock.qld.gov.au/silo/point-data/).

Results showed that the Mid North had a much longer and diverse flowering period for wheat and barley than the Riverland/Mallee. Interpolated temperature data was well matched with observed Mesonet data giving confidence that the interpolated PPD can be used for long term simulations. Rainfall data from the Mesonet weather stations did not match daily totals from PPD but monthly totals was a good fit. Long term simulation of days from sowing to flowering showed that elevation is a good descriptor for the delay in flowering across the environment for both barley and wheat. The project determined that flowering was delayed by 3-4 days with every increase in 100m above sea level.

Project objectives

The aims of the project were to:

- Characterise the environmental differences across the Mid North and SA Mallee to inform the planting time and variety selection of cereal crops
- Validate real-time thermal and vernalization data available on Mesonet and APSIM simulation data with on-ground truthing

Overall Performance

Achievement of Objectives
The project objectives were generally successful. The key finding of the project established that elevation is a useful descriptor for delay in flowering, particularly across the Mid North where there are large changes in elevation and the time to flower is diverse. The project also showed that interpolated PPD has a good fit with observed weather data recorded by Mesonet weather stations, and therefore is a high level of confidence in using PPD for long term simulations utilising APSIM.

<u>Personnel</u>

- Melissa McCallum
- SARDI Waite Agronomy team, particularly Dr Courtney Peirce, for supporting sowing and sampling activities on the ground and preparation of materials required.
- Access to Mesonet automated weather stations and weather data provided by COtL. Mesonet automated weather stations are on private properties across the Mid North and Riverland/Mallee.
- Damon Grace from COtL provided support for accessing data from the Mesonet

<u>Difficulties</u>

- Melissa McCallum went on maternity leave in 2023, the project was subsequently paused while she was on leave.
- During 2022, access to data from Mesonet weather stations was reduced due to a pay-to-view system being introduced.
- Dry seasonal conditions and mice activity limited the growth of plants at some sites and sowing times in 2022. However, the large number of sites and multiple sowing times means that there was success at majority of sites for at least one time of sowing.

KEY PERFORMANCE INDICATORS (KPI)		
KPI	**Achieved**	**If not achieved, please state reason.**
1 – Two time of sowing sown at selected Mesonet sites The number of Mesonet weather station sites was reduced to 24 (13 Mid North, 11 Riverland/Mallee) these sites were selected based on even spread of locations across the regions as well as site suitability and access. Two times of sowing were established the first between 26-28th of April and the second 1-3rd June. Sites were irrigated to ensure establishment. Late second time of sowing due to seasonal conditions and delay in opening rains across region.	Yes ☒ No ☐	
2 – Phenology data collected from field trials Sites were visited on a semi-regular basis between July and October and assessed for growth stage, primarily heading and flowering related phenology. Plants were also monitored and assessed for foliar diseases.	Yes ☒ No ☐	
3 – APSIM simulations run for Mesonet sites to ground truth observed results	Yes ☒ No ☐	Delayed. Simulations were delayed due to not being able to acquire weather data until the completion of the 2022 season and Melissa going on maternity leave from early 2023.
4 – Final Report	Yes ☒ No ☐	Delayed. The final report was delayed due to Melissa going on maternity leave from early 2023 and therefore unable to work on KPI 3 and 4 until her return.

TECHNICAL INFORMATION

Field experiment overview

There are 71 Mesonet automated weather stations spread across the Mid North and Riverland/Mallee regions of South Australia (as of June 2022).

In 2022, small observation plot trials were sown at 24 sites (Fig. 1) across the Mid North and Riverland/Mallee. There were two times of sowing (TOS) with all sites being sown over a three-day period. The first time of sowing was between the 26-28 of April and the second 1-3 June. All were sown with irrigation at an equivalent of 12mm rainfall to ensure germination and the best chance of establishment. These sites were then monitored between August and October to capture heading and flowering. Scepter, RGT Planet and Longsword were sown at each site and time of sowing. Establishment was variable, with better establishment from the early TOS in the Mallee, while the Mid North was better in TOS 2 due to seasonal conditions and the dry May limiting growth in the Mid North (data not shown). Average heading dates are shown in Table 1 for the two regions. There was greater variation in the observed flowering times in the Mid North than there was in the Riverland/Mallee (Table 1). This was a consistent trend across both time of sowing and variety.

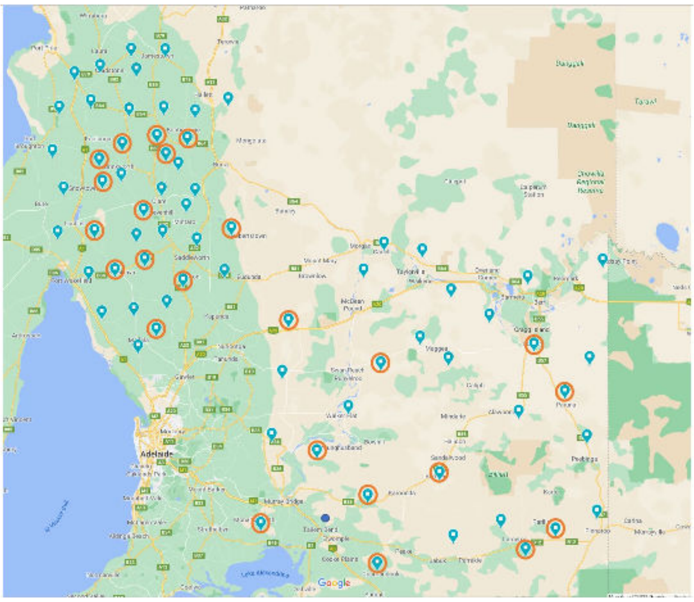

Figure 2: Map showing location of Mesonet automated weather stations across Mid North and Riverland/Mallee in 2021, including orange circled sites which were included in monitoring in 2021.

Figure 1: Small scale plot trials sown at the base of Mesonet weather station.

Table 1: Average range of observed flowering dates for RGT Planet, Scepter, and Longsword sown at a range of Mesonet sites across the Mid North and Riverland/Mallee across the two sowing times (TOS 1 = 26-28 April, TOS 2 = 1-3 June).

	Mid North		Riverland/Mallee	
	TOS 1	TOS 2	TOS 1	TOS 2
RGT Planet	19-31 Aug	15-24 Sept	15-20 Aug	16-20 Sept
Scepter	21Aug – 18Sept	21Sept – 1Oct	17Aug-1Sept	17-25 Sept
Longsword	25Sept – 5Oct	5-10 Oct	17-25 Sept	3-7 Oct

APSIM Flowering dates simulations vs observed flowering dates

Simulations were run to compare observed wheat flowering dates with those simulated using two difference sources of weather data (PPD and Mesonet derived data) (Table 2 and 3). These simulations for the 2022 season showed similar trends to the observed data (Table 1). The range in flowering dates across the Mid North was much greater with at least 20 days between the first and last site flowering. The difference in the Mallee was less with a range of only 10-13 days. RGT Planet and Scepter had similar lengths of flowering for each time of sowing and region. However, RGT Planet flowered earlier, starting and finishing flowering around a week earlier than the other cultivars. Longsword, as a winter wheat, was the slowest to flower and had the smallest range in flowering dates compared to the other varieties.

Table 2: Average range of simulated flowering dates for RGT Planet, Scepter, and Longsword sown at a range of Mesonet sites across the Mid North and Riverland/Mallee across the two sowing times (TOS 1 = 26-28 April, TOS 2 = 1-3 June) utilizing PPD for 2022.

	Mid North		Riverland/Mallee	
	TOS 1	TOS 2	TOS 1	TOS 2
RGT Planet	15 Aug – 9 Sept	22 Sept – 8 Oct	15 – 25 Aug	19 – 28 Sept
Scepter	20 Aug - 15 Sept	27 Sept - 13 Oct	20 - 31 Aug	23 Sep - 3 Oct
Longsword	14 Sept – 3 Oct	10 - 24 Oct	13 - 21 Sept	7 - 13 Oct

Table 3: Average range of simulated flowering dates for RGT Planet, Scepter, and Longsword sown at a range of Mesonet sites across the Mid North and Riverland/Mallee across the two sowing times (TOS 1 = 26-28 April, TOS 2 = 1-3 June) utilizing recorded weather data from Mesonet stations for 2022.

	Mid North		Riverland/Mallee	
	TOS 1	TOS 2	TOS 1	TOS 2
RGT Planet	18 Aug – 21 Sept	26 Sept – 15 Oct	18 – 31 Aug	24 Sept – 3 Oct
Scepter	24 Aug – 27 Sept	2 - 21 Oct	24 Aug – 6 Sept	29 Sept – 8 Oct
Longsword	18 Sept - 13 Oct	14 – 31 Oct	16 - 27 Sept	11- 20 Oct

Simulated flowering dates using the Mesonet weather data were later than the dates using the PPD weather data. The PPD simulated a flowering date around five days earlier but also shorter than the Mesonet simulated results by a further five days. This difference is likely driven by the small differences in recorded minimum and maximum temperatures. Temperatures recorded at the Mesonet sites had a good match with data from the gridded PPD (data not shown). Maximum temperatures had the best fit with R^2 value of between 0.97 and 0.99. There was a greater range for minimum temperatures but still a good fit with R^2 values between 0.77 and 0.93.

While this temperature difference is minimal as the APSIM simulations for growth stage and development are based off accumulated thermal time, and thus, any small differences can accumulate over time. This can be exacerbated if the difference in temperature is continuously in one direction, such as that observed at the Mesonet sites (12) Brinkworth and (13) Yacka. The difference between simulated flowering dates at Yacka for Mesonet and PPD weather data was 2-3 days. However, for Brinkworth the difference was between 5 and 15 days. This difference at Brinkworth was driven entirely by the majority of daily accumulated thermal time being lower for Mesonet data compared to the PPD. For the growing season (May-October) the difference was 1.27 degree day, however, for at least 23 days of the month, the Mesonet thermal time was less than the PPD. The difference in daily thermal time was similar for Yacka at 1.06 degree days, however, there was no trend of Mesonet thermal time being less than PPD. Therefore, the difference in thermal time accumulation was reduced. Brinkworth site had a lower elevation and had low minimum temperatures than Yacka, which was on the side of a hill. PPD is likely to overestimate minimum temperatures compared to the observed temperatures of the Mesonet. The PPD is also on a 5km grid with weather conditions averaged for the area.

One other limitation of APSIM modelling is that crop growth and development is driven entirely by accumulated thermal time and it ignores other environmental factors and their influence on growth stage progression. This is likely to be influencing the simulated results for TOS 2, which did not match the observed results. Neither frost nor drought/heat stress cause changes in crop growth stage when utilising APSIM to model growth. Only grain yield are affected in APSIM simulations but not growth stage progression. Therefore, there is no acceleration of crop growth stage due to high environmental stresses, such as heat and drought, or no slowing down of crop growth stage due to cooler temperatures in the APSIM simulated results.

While at some sites there was variation in the simulated flowering dates. The observed weather data has a good fit to PPD with a strong correlation between Mesonet weather data and PPD. Three years of Mesonet data was obtained for five sites (Yacka, Snowtown, Halbury, Navan, and Kybunga) and the correlation between Mesonet temperatures and PPD temperatures analysed. All had a significantly strong correlation with an R^2 value of between 0.95 and 0.98 (Figure 3a-e). Maximum temperatures had a better correlation than minimum temperatures (data not shown).
Rainfall did not tend to correlate. While individual days and rainfall events do not have a high correlation, the monthly and yearly totals matched at one site 13 Yacka (Fig 3f). The good match between observed Mesonet and PPD temperature data gives good confidence in utilising PPD for long term simulations of phenology.

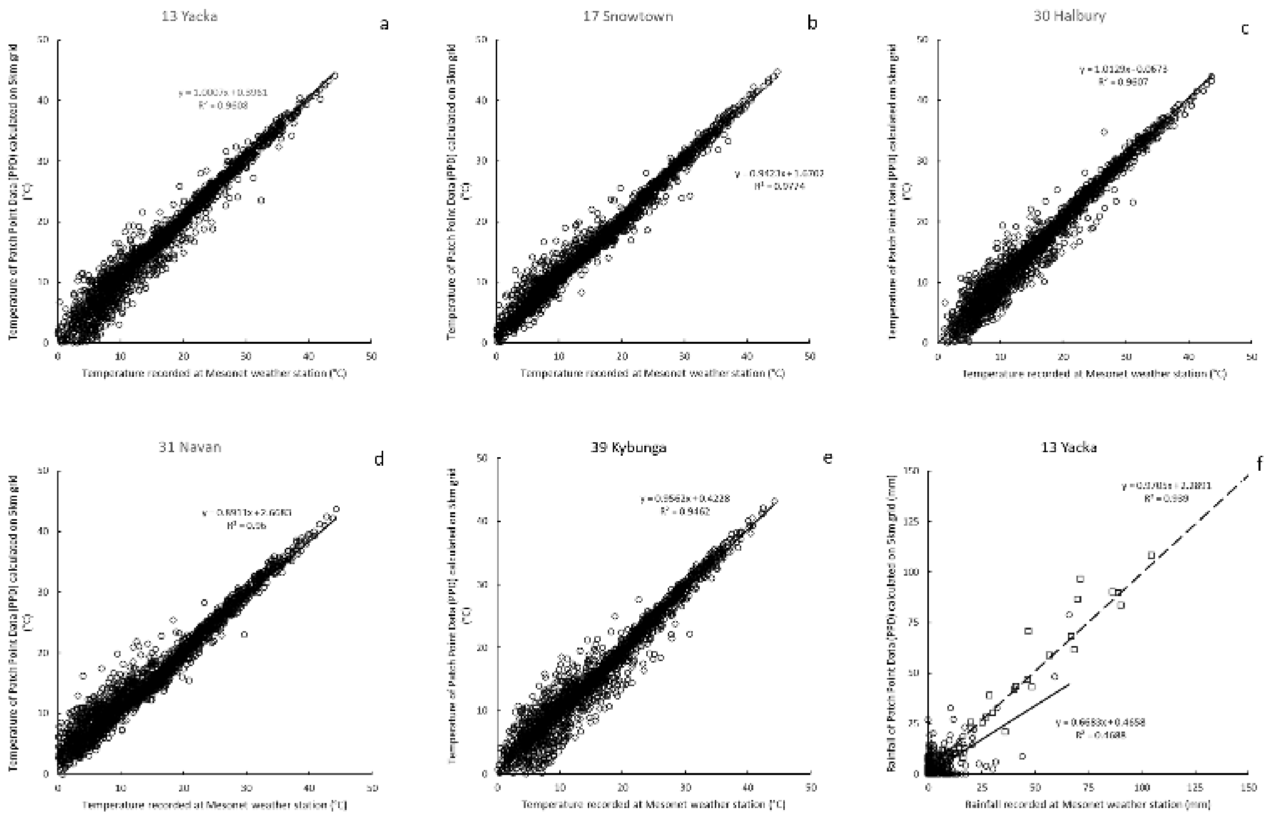

Figure 3: Comparison of observed temperature data at five Mesonet sites between 2020 and 2022 and the temperature data from PPD (a-e). f shows the rainfall data from 13 Yacka of 2020 to 2022 as both daily rainfall (circles) of observed Mesonet results and PPD and monthly totals (squares).

Long term simulation of flowering dates

Simulations were run for the 1st week of May sowing dates from 1970 to 2020 utilising varieties with similar development speeds to RGT Planet, Scepter, and Longsword. These results were translated into the number of days from sowing to flowering. Maps were created using the Mesonet locations to show the variation in time to flower across the two regions (fig 4). There was the greatest variation across the Mid North, consistent with observed flowering results. First to flower was the western side of the Mid North closest to the coast as well as the north of the Riverland/Mallee. In the Mid North in general flowering progressed from west to east. While in the Riverland/Mallee it started in the north and finished in the south. The trend was the same for the three varieties, with the winter wheat taking the longest to flower on average and a difference of about 5 days between the mid-quick wheat and quick barley.

Figure 4: Average time to flower from sowing in the first week of May for a quick-mid spring wheat (a), quick spring barley (b), and quick winter wheat (c).

One way to explain the time to flower and variation across both regions is due to differences in elevation. There was a strong relationship between days to flower and changes in elevation. Figure 5, shows the correlation between elevation and delay in flowering for the three varieties. For a winter wheat, there was a delay in flowering of 3.2 days for every 100m increase in elevation, for a quick spring barley it was 3.7 days and a quick-mid spring wheat the change was 4 days. Elevation may be a useful way to categorise the environmental differences across the Mid North and Riverland/Mallee.

Optimal flowering time

Optimal flowering time and optimal sowing period for these regions was not able to be modelled due to the lack of good soil characterisation. While APSIM is only reliant on thermal time for phenology. Yield is driven by environmental conditions including water availability, which is highly linked to soil characteristics. For accurate optimal flowering and sowing periods, soil characterisations are required for each Mesonet site.

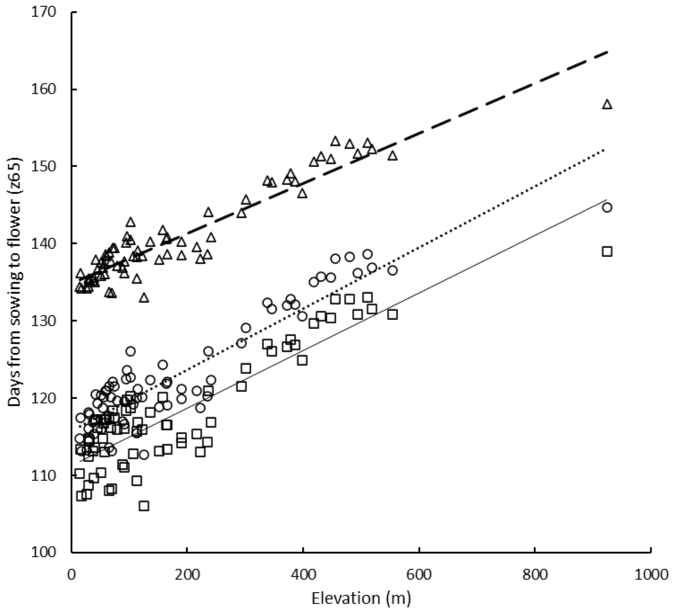

Figure 5: Influence of elevation on the delay in flowering from a May sowing date for a quick-mid spring wheat (circles, $R^2 = 0.85$, $y = 0.0396x + 115.71$), quick spring barley (squares, $R^2 = 0.78$, $y = 0.0373x + 111.29$), and a quick winter wheat (triangles, $R^2 = 0.88$, $y = 0.0324x + 134.88$).

CONCLUSIONS REACHED &/OR DISCOVERIES MADE

The time to flower has a higher level of variation across the Mid North than the Riverland/Mallee region. This was shown consistently with observed results and simulated results utilising a range of weather data sources. Long term modelling suggests that the variation in the Mid North was around 25 days, while for the Riverland/Mallee it was only 12 days. The difference was less for winter wheats as the vernalisation control reduces environmental variations.

Interpolated PPD was a good fit for long term modelling and matched observed temperatures, the rainfall data was more variable but monthly totals had a good fit with observed data. This gives confidence in using PPD for long term simulation of growing seasons using APSIM.

Elevation was a good factor for explaining the differences in time to flowering across both the Mid North and Riverland/Mallee. There was a strong correlation between days from sowing to flowering and elevation, with the time to flowering increasing by 3-4 days with every increase in 100m of elevation depending on variety development speed. The results of this study is one way the Mid North region can be further categoried to understand the time to flower and effect on sowing date and optimal flowering window. Greater characterisation of soil types across the region is needed to accurately define both optimal sowing and flowering windows.

INTELLECTUAL PROPERTY

All Mesonet input weather data is owned by Mesonet.

APPLICATION / COMMUNICATION OF RESULTS

Main Findings

- Riverland/Mallee has a succinct flowering period across the region. The Mid North has much greater variation in time to flower, irrespective of crop type or variety.
- Observed flowering dates generally matched simulated results (both Mesonet derived weather data and PPD), later sowing dates did not match as well.
- Interpolated PPD was well matched to observed temperatures.
- Rainfall data had greater variability, but monthly rainfall totals had a good match between PPD and observed Mesonet totals.
- Elevation can be used to describe time to flower, with increases in 100m delaying flowering by 3-4 days.

Potential Industry Impact

This research provides a good basis for quantification of environmental variation across the Mid North and Mallee of South Australia. Elevation is a good factor for explaining the variation in temperature across the region and therefore the differences in thermal time accumulation. The link between elevation and the delay to flower is a useful way to classify areas and have a greater understanding of the impact of time of sowing and variety selection.

Communication

Opportunities for communication of this project were limited. Furthermore, due to maternity leave and Melissa changing roles (moved to Vetch breeding), communication in 2023-24 was further limited.

During the SAGIT visit in August 2022, AgCommunicators recorded a video for promotion.

Flowering time maps and details have been provided for inclusion in further SA Sowing Guides.

POSSIBLE FUTURE WORK

The next step for characterisation of the environmental differences across the Mid North and Mallee is to determine the soil characteristion of each site and match with available APSIM soils. APSIM is reliant on both weather conditions and selected soil for accurate simulations. To simulate and define the optimal flowering period, as described by Flohr (2014), accurate soil characterisation is needed. Moisture availability and responses to environmental stresses are highly linked to the soils water holding capacity and this affects yield and therefore the definition of the optimal flowering period for an environment. Currently there are a limited number of soil characterisations available within APSIM and this limits the ability to simulate a higher number environments across the Mid North and Riverland/Mallee to create optimal sowing and flowering windows.

Once there is a higher number of soil characterisations available in APSIM, modelling can be completed to further characterize the optimal sowing times for these regions. The effect of elevation on delaying flowering can be used to target different environments within the regions. This could then create nice maps as to when sowing should occur to target flowering of certain developmental speed varieties within the optimal flowering period.