FINAL REPORT 2015

Applicants must read the *SAGIT Project Funding Guidelines 2014* prior to completing this form. These guidelines can be downloaded from www.sagit.com.au

Final reports must be emailed to admin@sagit.com.au as a Microsoft Word document in the format shown ***within 2 months*** after the completion of the Project Term.

PROJECT CODE	:	UA1203

PROJECT TITLE	Manipulating seed nutrient content to improve vigour and yield in wheat

PROJECT DURATION

*These dates **must** be the same as those stated in the Funding Agreement*

Project Start date	1 July 2012
Project End date	30 June 2015

PROJECT SUPERVISOR CONTACT DETAILS

The project supervisor is the person responsible for the overall project

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Office Use Only

Project Code	
Project Type	

ADMINISTRATION CONTACT DETAILS

The Administration Contact is the person responsible for all administrative matters relating to the project

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PROJECT REPORT

Provide clear description 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 worked examined the effects of seed source, seed size and seed nutrient concentration on yield in wheat in a series of field trials across SA. .Grain nutrient concentrations varied considerably between sites and seed source influenced yield. Seed from low fertility sites can produced yields that may be 10% lower on average than yields using seed from sites with higher fertility. Seed P concentration was the nutrient most commonly associated with yield and it was estimated that using seed with a P concentration 4000 mg/kg compared to 3000 mg/kg would improve yield by about 3%. Grading seed did not influence seed nutrient concentrations.

Using higher fertiliser rates and foliar sprays to increase the concentrations of protein and macro- and micronutrients (nutrient loading or 'supercharging)' enhanced grain nutrient concentrations but failed to demonstrate improvements in growth or yield of wheat. This may have been associated with the small improvements in grain P concentration from these treatments as standard fertiliser treatments were not very effective in increasing grain P concentrations.

Using large seed improved crop establishment and crop vigour but did not always improve yield. The benefits of large seed were only achieved at higher yielding sites and it would appear there is little or no benefit where yields are lower than 2-2.5 t/ha. Using large seed increased yields by up to 5% on average. Neither seed source nor seed size influence the quality of the wheat crop.

The work has demonstrated that using large seed with a high P concentration can improve

yields by up to 10%, but the greatest benefit will be in higher yielding environments.

Project Objectives

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

The primary aim of this project to quantify the benefits of seed quality to early vigour and yield in wheat on different soil types in SA.

To achieve this aim we will:

(i) Assess the relative importance of grain protein, seed mineral nutrient concentrations and seed physical properties on yield
(ii) Examine the effect of these traits on different soils and at sites with different yield potentials
(iii) Provide guidelines on the best agronomic practices to maximise seed quality
(iv) Compare the agronomic and economic value of different strategies to enhance grain nutrient quality

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.

Overall the project achieved its aims and there were relatively few difficulties encountered. There was only one experimental failure, in a trial at Swan Reach in 2013 due to a high level of rhizoctonia and accidental grazing by sheep. This trial was abandoned.

The field trials did not intentionally target sites when soil fertility was low. It is well established that high seed nutrient concentrations can improve growth and yield where soil nutrient availability is low (eg high seed Mn in a low Mn soil). The aim of this work was to examine the importance of seed quality at sites where the background level of nutrition was reasonably high and thereby provide information and recommendations at sites representative of large parts of the cereal zone, rather than situations of chronic nutrient deficiency.

The major limitation to the trial work was the failure to alter seed P concentration greatly in the seed nutrient loading work at Warooka and Turretfield given that the data suggest that seed P is important. This limited the ability to investigate fully the benefits of enhancing grain P concentrations. However previous work conducted by SARDI on 'supercharging' wheat grain also found relatively small shifts in grain nutrient concentrations with additional fertiliser.

<u>Collaborators</u>: Ms Shafiya Husseini (SARDI, now with Longreach Breeding) and Mr Leigh Davies (MAC). The trial program was managed by SARDI Field Crops Evaluation Unit under the leadership of Mr Rob Wheeler.

Key Performance Indicators (KPI)

*Please indicate whether KPI's were achieved. The KPI's **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.*

	(Y/N)	
KPI 1a: Plots to generate seed treatments for 2013/14 season sown Seed increase plots of Mace sown at Warooka and Turretfield. Nitrogen, P and trace element treatments imposed.	Y	
KPI 1b: Year 1 trials harvested and analysed Experiments on effects of seed source, variety and seed size sown at Minnipa and Turretfield sown and harvested.	Y	
KPI 1c: Grain analyses from Year 1 completed Grain analysis is completed and data have been statistically analysed	Y	
KPI 2a: Plots to generate seed treatments for 2014/15 season sown Seed increase plots of Mace sown at Warooka and Turretfield. Nitrogen, P and trace element treatments imposed from booting to dough stages.	Y	
KPI 2b: Year 2 trials harvested and analysed Experiments on the effects of seed source, variety seed size were sown at Minnipa, Karoonda and Turretfield Mace seed generated in 2013 with different nutrient profiles was sown in trials in 2014	Y	
KPI 2c: Grain analyses from Year 2 completed Grain analysis is completed and data have been statistically analysed	Y	
KPI 3a: Year 3 trials harvested and analysed Trials were run at Minnipa, Karoonda and Turretfield. All trials have been harvested and results analysed and grain quality completed.	Y	
KPI 3b: Submission of final report to SAGIT	Y	

Technical Information (Not to exceed **three** pages)

Provide sufficient data and short clear statements of outcomes.

Two sets of trials were conducted between 2012 and 2014.

A. Effect of seed source

Seed from NVT trials from SA were used in the experiments. Initially a sample of Mace seed from a number of NVT trials was analysed for grain nutrient concentration and protein and these results were used to select the seed sources for the year's work. The seed from each selected site was graded into two sizes (>2.8 mm and 2.5-2.8mm) in 2012 and 2013 and three sizes (2.2-2.5, 2.5-2.8 and >2.8 mm) in 2014. The protein concentration and grain nutrient concentration was measured for each size class. Between three and seven varieties were grown in the experiments. The trials were grown at Minnipa and Turretfield (2012-2014) and Karoonda (2013-2014).

B. Effects of seed nutrient loading

Mace wheat was grown at Warooka and Turretfield and a number of late-season nutrient treatments imposed to manipulate seed nutrient concentration. Additional N (15 kgN/ha as foliar urea) and micronutrients (2 kg/ha of Zn, Mn and Cu as a foliar spray) were applied at the following developmental stages: flag leaf emergence, booting, watery ripe and soft dough. Additional P was applied at sowing to promote P uptake and grain P. There were 12 treatments, combining 3 fertiliser treatment (N, N+P, N+P+micronutrients) and 4 times of application. Based on the nutrient analysis of the seed, a subset of samples showing the widest range in grain nutrient concentrations was selected for trial work in the following year.

RESULTS

Variation in grain nutrient concentrations

Average values for nutrient concentrations of Mace were consistent with previously reported concentrations from SA, but there was up to a 3-fold variation in nutrient concentrations among the sites (Table 1). Seed from Nangari in the mallee consistently had the lowest grain nutrient concentrations and seed from Turretfield generally had the highest nutrient concentrations (Table 2)

Table 1. Average, standard deviation (SD) and the minimum and maximum values for grain of Mace wheat sampled from NVT trials in SA in 2011-2013. The averages for South Australia from an earlier survey by Norton and the critical values for grain nutrients reported by Reuter and Robinson are also shown

	GPC	Fe	Mn	B	Cu	Zn	Mg	K	P	S
Mean	11.0	29	40	1.7	3.9	18	1154	3909	2715	1434
Std dev	1.71	4.7	8.5	0.74	1.08	4.2	105.3	435.0	535.0	162.1
Minimum	8	16	26	0.9	1.4	9	990	3300	1600	1090
Maximum	15	38	62	3.6	5.3	29	1340	5000	4000	1720
SA average		30	41	1.9	4.9	23	1278	4641	3354	1729
Crit. value			20	<2	1-2.5	5-15		5000	2700	1200

Table 2. Mean nutrient concentrations in Mace wheat from trials 2011-2013 at three NVT sites

	GPC	Fe	Mn	B	Cu	Zn	Mg	K	P	S
Nangari	9.8	27.8	34.6	2.3	4.2	10.8	1047	3300	1863	1390
Turretfield	12.2	31.8	45.4	1.1	4.8	19.0	1260	4467	3467	1543

Effect of seed source on yield

Seed source significantly influenced yield in six of the eight experiments but the effects were small and were sometimes dependent on the variety and/or seed size. At Minnipa and Turretfield the source of seed affected yield in two of the three years of trials but at Karoonda yield was not affected by seed source in either year. The average yield difference between the best and worst seed sources was 5-10%. Where the effect of seed source interacted with either variety or seed size, there was no consistent pattern in the data. Seed from Nangari generally produced the lowest yields while seed from Turretfield generally produced the highest. An example of the differences in growth is given in Appendix 1. No single grain characteristics could explain the effect of seed source in every case, but of the grain nutrients, P, K and to a lesser degree Zn were commonly associated with variation in yield. This was the same whether the concentration of the nutrient (mg/kg) or the mass of the nutrient (mg/seed) was considered. Based on the relationships between yield and grain P concentration for seed from the different sites, it was predicted that using seed from a site where P concentration was 4000 mg/kg compared to one with 3000 mg/kg could improve yield by 2-3%. At a grain price of $270/t this equates to an additional $5-8/t/ha, so at a base yield of 3t/ha it would be equivalent to an additional $15-24/ha.

In 2013 seven varieties were compared and seed source significantly affected the rankings of varieties. While varieties like Gladius, Mace and Scout ranked consistently with all seed sources, Estoc, AGT Katana and to some extent Emu Rock showed different rankings depending on seed source (Table 3): for example, with seed from Wanbi, Estoc was the highest yielding variety (3.34 t/ha) but with seed from Booleroo (2.79 t/ha), Mitchellville(2.87 t/ha) and Wolsely (2.71 t/ha) it was the lowest yielding variety. Similarly Emu Rock grown using seed from Booleroo (3.69 t/ha), Nunjikompita (3.61 t/ha), Mitchellville (3.35 t/ha) and Wanbi (3.37 t/ha) performed well, but if seed from Nangari (2.85 t/ha) or Turretfield (3.29 t/ha) was used it ranked poorly. Ideally, varieties should be compared with seed from the same source to overcome potential confounding effects.

Table 3. Ranking of varieties from seed from different NVT trials when grown at Turretfield in 2012. Yields are ranked within each seed source, with rank 1 = highest yielding variety.

Vriety	Source of seed						
	Booleroo	M'ville	Nangari	Nunjikompita	Turretfield	Wanbi	Wolseley
AGT Katana	5	3	6	2	1	3	5
Emu Rock	1	2	5	1	5	2	2
Estoc	7	6	3	4	3	1	7
Gladius	6	6	7	6	6	7	6
Mace	2	1	1	3	2	5	1
Magenta	4	5	4	5	7	6	3
Scout	3	4	2	-	4	4	4

Seed size and seed nutrient concentration

Nutrient analysis of the graded seed from 2012 and 2013 showed no consistent effect of seed size on grain protein or nutrient concentration in the grain. An example is given in Table 3. While thousand grain weight differed by more than 2x there was relatively little variation in nutrient concentrations.

Table 3. Thousand grain weight and nutrient concentration in different size categories for seed from Nangari.

Seed size (mm)	TGW (mg)	GPC (%)	P	K	S (mg/kg)	Zn	Mn
<2	15.6	10.8	1830	3566	1363	10	31
2-2.5	28.2	10.4	1755	3725	1335	10	33
2.5-2.8	39.5	10.5	1833	3796	1353	10	34
>2.8	48.9	11.3	2046	3773	1450	11	36

Effect of seed size on yield

Grading seed into small and large sizes improved crop establishment and crop vigour but the effect on yield depended on the site at which the experiment was sown. The benefits of large seed were greatest at higher yielding sites: over two years at Karoonda we could not demonstrate a benefit of larger seed but there was a consistent benefit at Turretfield (Fig 1). The maximum average yield benefit if using large seed was of the order of 5% at Turretfield.

Effects of late season nutrient applications on seed quality and yield

Applying foliar sprays after flag leaf emergences was effective in increasing micronutrients and grain protein in the seed. Doubling the amount of P fertiliser applied caused only a small change in grain P concentration. Foliar applications were most effective when applied between booting and early grain fill, although increases in grain Zn and Mn are possible with later applications if the canopy does not senesce rapidly. Grading the seed did not affect the treatment differences, a result that was consistent with grading seed from the NVT trials.

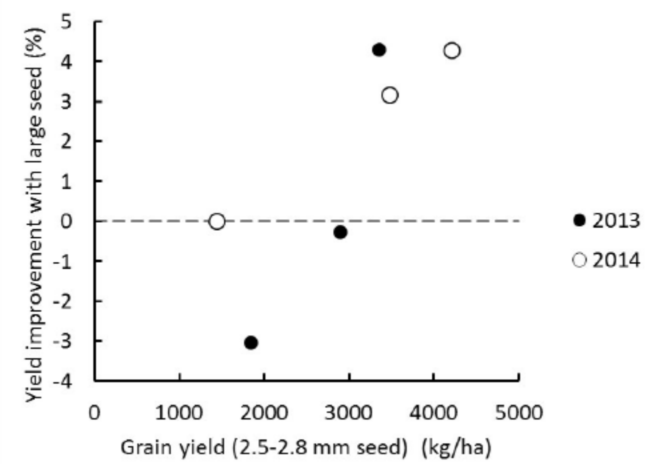

Figure 1. The yield advantage associated with using large seed. The results suggest greatest benefits at sites where yields are higher than approximately 3 t/ha.

Using seed of Mace grown at the same site but with differences in grain protein and micronutrient concentration did not result in large or consistent differences in crop vigour or differences in yield. The differences in grain P concentration in this seed were relatively small and may not have been sufficiently large have an influence on yield. These results suggest that enhanced seed nutrient concentrations may have limited impact on growth and yield where the background levels of fertility are reasonably high.

Seed size had a more consistent effect and using larger seed compared to the ungraded control tended to improve crop vigour and yield. However, as with the seed source trial (Figure 1) , the effect of seed grading was greatest at the high yielding sites (Turretfield 2013, 2014 and Minnipa 2014) and there was no advantage at the two trials at Karoonda.

Conclusions Reached &/or Discoveries Made (Not to exceed one page)

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

The work confirmed the importance of seed source to yield and emphasized the penalties associated with using seed from low fertility sites. The sizes of the yield benefits found in the current work are consistent with the few previously published results on seed nutrient enhancement in SA. However, it is often assumed that benefits from high quality seed are equally expressed in all environments, but an important result of the work was that it demonstrated that this may not be true.

While the work showed there are benefits to yield of up to 10% from using larger seed or seed of high P concentration these benefits are only realized where yields higher than about 3 t/ha can be anticipated. Crop establishment and crop vigour were enhanced by using high quality seed but in the two years of trial work there was no yield benefit from manipulating seed quality when yields were below about 2.5 t/ha. Therefore it is farmers in higher yielding environments who are likely to benefit most from using high quality seed. The caveat to this is where crops are grown in soils deficient in one or more nutrients, in which case high seed nutrient concentration can help alleviate the effects of nutrient deficiencies.

Grading seed was not effective in changing seed nutrient profiles and the benefits from grading will the ability to use larger seed rather than enhanced nutrient profiles.

In one year seven varieties were compared and while limited the results showed that the source of seed can influence the ranking of varieties. This has implication for trials involving comparisons between varieties and emphasises that best practice should use seed grown under the same conditions to avoid confounding effects of seed source.

Seed source and seed size has little to no effect on grain quality (Appendix 5). The over-riding influence of seed quality is on crop vigour and yield.

Intellectual Property

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

No IP was generated from this project

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.

1. Main findings
    - Yields of wheat can vary by about 10% on average depending on the source of the seed.
    - Seed from low fertility sites will tend to produce low yields.
    - Grain P seems to be an important cause of this variation, but not exclusively.
    - There was some evidence that the relative performance of varieties may alter depending on the source of the seed.
    - Even when grown under well managed conditions, seed nutrient concentrations can vary among varieties as well as sites. Grain nutrient analysis should be used

to check the nutrient levels in grain.

- Using large seed or graded seed improved yields by up to 5% but the yield benefit depended on the site.
- Grading the seed was not an effective way to alter nutrient profiles in the grain because it did not significantly shift the nutrient concentrations.
- Improvements in seed quality will be most beneficial in high yielding environments. There appears to be little benefit at sites where yields are less than 2-2.5 t/ha
- Late foliar application of micronutrients and N targeting the period from flag leaf emergence to early grain fill can enhance seed nutrient concentrations.

2. Potential industry impact
    - Growers, especially those achieving high yields, should to be aware of the potential effect of seed source and size to yield.
    - There may be limited to no benefits to yield of higher seed quality in lower yielding environments.
    - Seed nutrient concentrations can vary 2-3 fold depending on source and even when grown under high levels of management such as the NVT trials, grain with nutrient levels below critical values can be produced. Grain analysis is an effective means of assessing grain quality.
    - Variation in relative yields among varieties due to seed source means that variety comparisons should ideally use seed from the same site. This confirms the practice currently adopted by NVT and GRDC.

3. Publications and extension material
    - A summary of the results were presented in the EP Farming Systems Result summary in 2013 and 2014 (Appendices 2-4)
    - The trial work was presented at the MSFS field days in 2013 and 2014
    - The results were presented to a meeting of the SA Crop Science Society (August 2015)

POSSIBLE FUTURE WORK

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

1. *Enhancing seed P*

    There is limited information on the ability to manipulate seed P concentration by fertiliser management. The few published data show little change in grain P with foliar P, but the grain P levels were high to start with.

    An associated question is whether there is a maximum P concentration beyond which there are no longer benefits. The current work showed potential yield gains with P concentrations up to 4000 mg/kg at some sites, a value well above the state average

2. *Better defining the environments that will benefit from high seed quality*

The lack of response in experiments where yields were less than 2-2.5 t/ha was unexpected and suggest that farmers in lower yielding environments may not need to be too concerned about seed quality as long as the background level of soil fertility is adequate. However this conclusion is based in results from a single site (Karoonda) and the consistency of this effect should be examined more broadly.

AUTHORISATION
Name:
Position:
Signature:
Date: