ABSTRACT: 431

INVESTIGATING THE EFFECTS OF LOCATION ON SEED PERFORMANCE

SHANAHAN P[1*] & JARVIE A[2]

[1]School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal
P. Bag X01, Scottsville 3209, Pietermaritzburg, South Africa
[2]Pannar Seed (PTY) Ltd, P.O. Box 19, Greytown 3250, South Africa

E-mail: shanahan@ukzn.ac.za

Much research has been conducted on the merits of professionally produced soybean seed versus farm retained seed. However, in South Africa, some farmers claim that the improved performance of retained seed is as a result of the seed acquiring acclimatisation to their environmental conditions. An experiment was designed to test the validity of this claim. High quality seed lots of two different soybean cultivars, PAN1454R and A5409RG, were obtained from four diverse locations. These seed lots were all planted at each of the four locations during the 2009/10 season. This was repeated in the 2010/11 season with the four seed lots obtained from the trial plots of the respective locations of the 2009/10 season.

The trials were conducted using a row x column design, with a gross plot of 4 rows x 4.5 m, replicated three times. The inner two rows of the plots were harvested and seed mass was converted to 12.5% moisture. As Location 4's trial failed in the 2009/10 season and Location 3's trial failed in the 2010/11 season, the data for each season were analysed separately using the REML Meta-analysis procedure in Genstat version 14. All interactions were significant in both seasons except for Cultivar x Location x Seed source in 2009/10.

In order to test the theory of acclimatisation, the yield of the seed lot in the environment of its origin was compared to the best performing seed lot at that location. With one exception, seed grown at the location of origin was not the best performing seed for both cultivars in both seasons. Seed grown at its origin (meaned across cultivars) in Season 2009/10 was lowest performing at Locations 1 and 2, and second lowest at Location 3; while in Season 2010/11, it was second lowest performing at Location 1, second highest at Location 2, and the exception, highest performing at Location 4 (largely due to the performance of A5409RG). No single source of seed was consistently superior or worse than the rest at any of the locations over both seasons. Averaged over locations and seed source, PAN1454R was significantly ($p<0.001$) superior to A5409RG in Season 2009/10 whereas A5409RG was significantly ($p<0.001$) superior to PAN1454R in Season 2010/11. It was apparent that consistency of the performance of the cultivars within each season was affected by seed origin. Since there was no evidence for consistent, positive acclimatisation and, indeed, evidence for negative acclimatisation in this dataset, there is a greater production risk of using seed at the location of origin.

Investigating the effects of location on seed performance

Paul Shanahan
&
Antony Jarvie


INTRODUCTION

The genetic and epigenetic factors that affect seed quality and subsequent performance of the crop wherever the seed originates are numerous and varied:

- Seeding date and sowing depth
- Seed size (correlated with seedling size), mass and shape
- Seed size may affect adult traits in non-cultivated plant species
- ABA dependent or independent metabolic processes are influenced by environmental stresses

- Small differences in *temperature* conditions of the maternal plant affect seed mass and germination response
- Different *photoperiods* at early stage of floral induction may affect seed mass as well as induce changes in seed coat structure and permeability
- *Light quality* that the maternal plant is exposed to affects the germination condition requirements of the seed

- Seed mass may be influenced by the nutrient availability in the maternal environment; however, the mass and mineral concentrations of the seed in some plant species remain constant despite large variations in the maternal nutrient environment
- Improving maternal nutrient environment has been found to affect germination rate, and several growth traits and reproduction of the progeny as well as relative competitive ability of the resulting seedlings
- Nutrient deficiency (Ca, Mg, Mo, Bo, Si, etc.) and/or toxicity (Al, Mn, Na, Cl, etc.) in the maternal environment is well documented to affect seed development, germination and subsequent vigour of seedlings and mature plants

- Seed mass often decreases when the maternal parent is grown at *high population density*
- Seed mass and germination affected by *water stress* in the maternal environment
- Maternal affects may persist for more than one generation
- Pollen parent is known to affect seed size and mass so obviously paternal genetic contribution is important
- Heritability of seed mass is high in cultivated plant species and low but significant in non-cultivated species

- Diseases in the maternal environment and diseases in the progeny environment affect seed quality and subsequent crop performance
- Beside the requirement for inoculation with beneficial symbiotic N-fixing bacteria in legumes such as soybean there are a host of interactions with symbiotic and parasitic endo- and exophytes that may affect seed quality and subsequent crop performance

- Beneficial microbes may protect the developing seed in the maternal environment and inoculating seed with beneficial microbes may improve resistance of seed and subsequent crop to biotic and abiotic stresses
- Beneficial endophytes enhance root development, growth and reproduction in plants grown in soil native to the endophyte
- Habitat-specific endophytes are passed to the next generation on seed coats and this may cause plant genotypes to be stable only within the habitat preferred by the resident endophytes

These factors and others may underlie the variation in performance of seed that is produced under different environmental conditions and then planted and grown in those same and different environments

The objective of this study was to:

Evaluate the effect of seed origin on subsequent yield in soybean

In terms of this objective there are two contrasting points of view that provide for testable hypotheses:

- **Due to acclimatisation, seed performs better in the originating environment than bought seed**

AND CONVERSELY

- **Regardless of origin, the best quality seed (based on pre-season germination and vigour tests) should prevail across all environments**

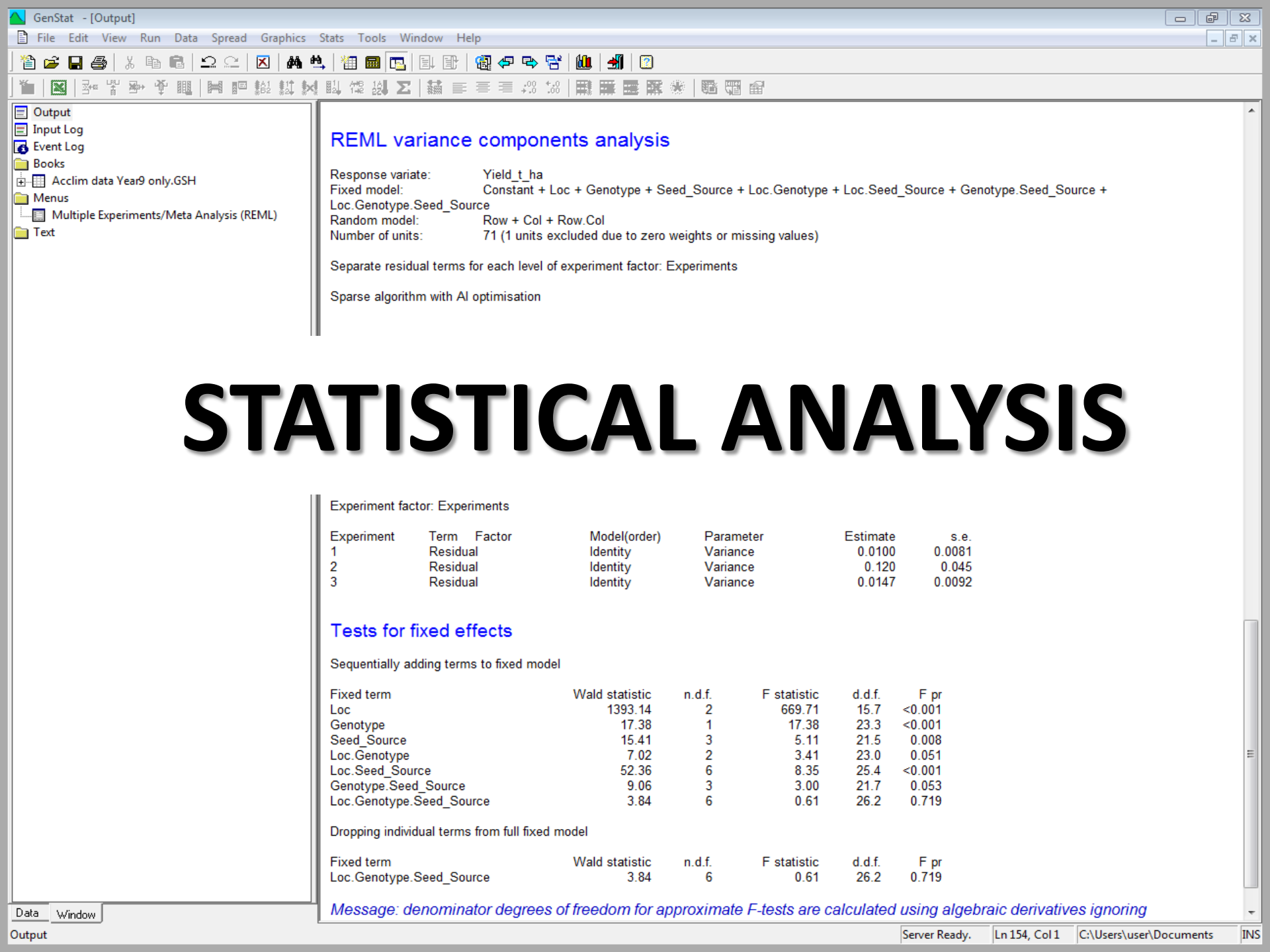
EXPERIMENTAL PROCEDURE

- In 2008 seed of two soybean cultivars, PAN1454R and A5409RG was sourced from four different locations – L1, L2, L3 and L4
- All four seed sources: SS-L1, SS-L2, SS-L3 & SS-L4, had >92% germination in pre-season testing for both season's trials
- In the 2009/10 season all four seed sources of both cultivars were planted at each of the four locations
- This was repeated in the 2010/11 season with the four seed sources for the two cultivars obtained from the trial plots of the respective locations of the 2009/10 season's field trials

- A row x column design was used with a gross plot size of 4 rows x 4.5 m, replicated three times to determine the Cultivar, Location and Seed Source main and interaction effects
- The inner two rows of the plots were harvested and seed mass was converted to 12.5% moisture and expressed in t ha^{-1}

Location descriptions

Location	Altitude	Rainfall
L1	Mid-altitude ±1012 masl	Non-irrigated >800 mm
L2	Mid-altitude	Irrigated
L3	Mid to high altitude	Non-irrigated ±800 mm
L4	High altitude ±1580 masl	Non-irrigated ±550 mm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REML variance components analysis
Response variate: Yield_t_ha
Fixed model: Constant + Loc + Genotype + Seed_Source + Loc.Genotype + Loc.Seed_Source + Genotype.Seed_Source + Loc.Genotype.Seed_Source
Random model: Row + Col + Row.Col
Number of units: 71 (1 units excluded due to zero weights or missing values)
Separate residual terms for each level of experiment factor: Experiments
Sparse algorithm with AI optimisation
STATISTICAL ANALYSIS
Experiment factor: Experiments
Experiment Term Factor Model(order) Parameter Estimate s.e.
1 Residual Identity Variance 0.0100 0.0081
2 Residual Identity Variance 0.120 0.045
3 Residual Identity Variance 0.0147 0.0092
Tests for fixed effects
Sequentially adding terms to fixed model
Fixed term Wald statistic n.d.f. F statistic d.d.f. F pr
Loc 1393.14 2 669.71 15.7 <0.001
Genotype 17.38 1 17.38 23.3 <0.001
Seed_Source 15.41 3 5.11 21.5 0.008
Loc.Genotype 7.02 2 3.41 23.0 0.051
Loc.Seed_Source 52.36 6 8.35 25.4 <0.001
Genotype.Seed_Source 9.06 3 3.00 21.7 0.053
Loc.Genotype.Seed_Source 3.84 6 0.61 26.2 0.719
Dropping individual terms from full fixed model
Fixed term Wald statistic n.d.f. F statistic d.d.f. F pr
Loc.Genotype.Seed_Source 3.84 6 0.61 26.2 0.719
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- As Location 4's trial failed in 2009/10 and Location 3's trial failed in 2010/11, the data for each season were analysed separately in the REML Meta-analysis procedure, Genstat 14
- Location, Cultivar and Seed Source were declared as fixed effects and rows and columns as random effects
- All interactions of the fixed effects were significant ($p \leq 0.05$) except for Cultivar x Location x Seed Source in 2009/10


RESULTS AND
DISCUSSION

Testing the hypothesis of acclimatisation

If acclimatisation occurs then for both cultivars the following ranking would be expected:

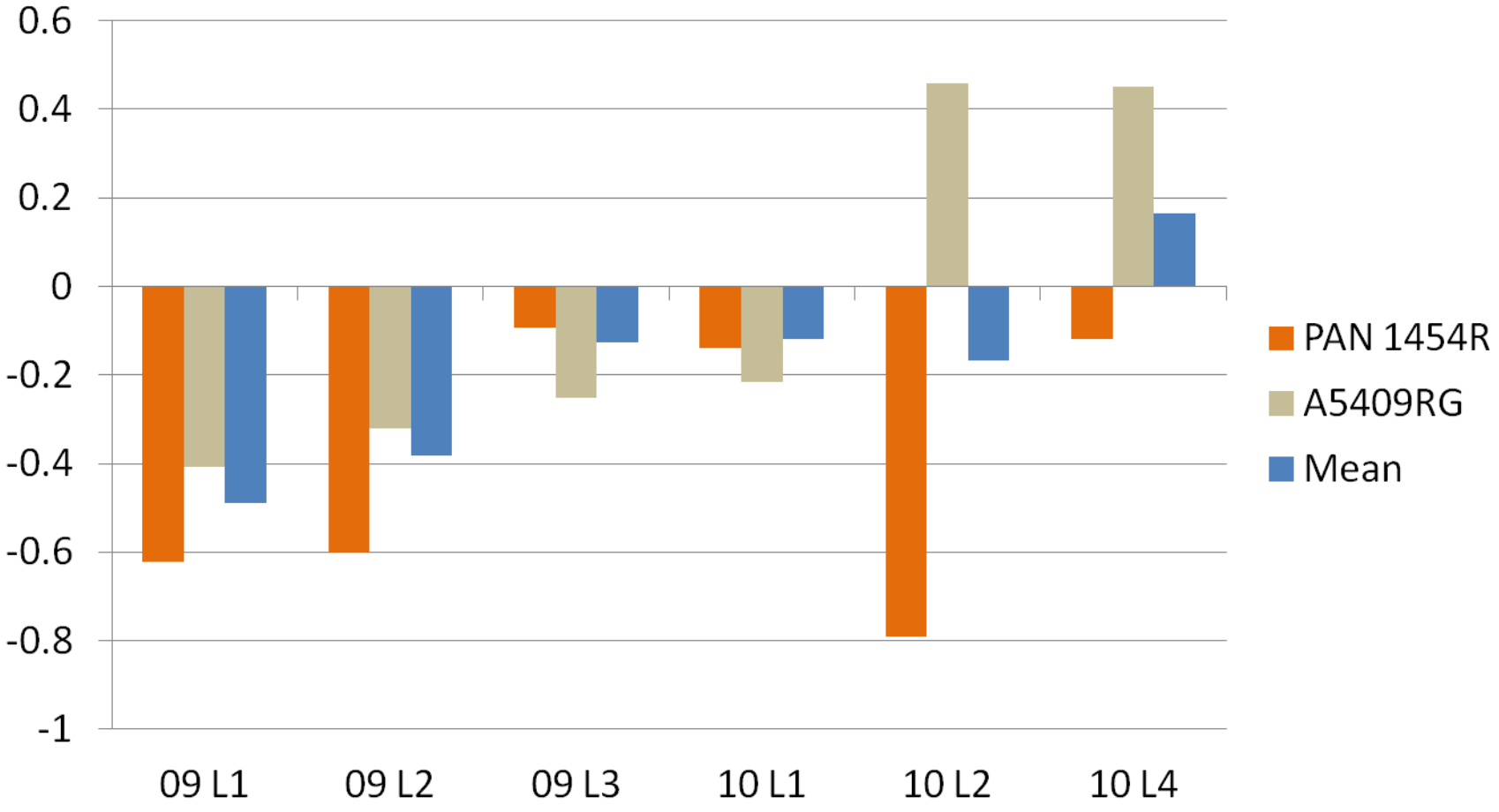
		Seed Origin			
		SS-L1	SS-L2	SS-L3	SS-L4
Trial Location	L1	1			
	L2		1		
	L3			1	
	L4				1

The following trends presented from the trial data:

Within cultivar ranking (WR) and overall ranking (OR) for performance of each seed source at its location of origin

	SS-L1 at 09 L1		SS-L2 at 09 L2		SS-L3 at 09 L3		SS-L1 at 10 L1		SS-L2 at 10 L2		SS-L4 at 10 L4	
	WR	OR	WR	OR	WR	OR	WR	OR	WR	OR	WR	OR
PAN 1454R	4	8	4	8	2	2	3	7	4	5	2	6
A5409RG	4	7	4	7	3	7	3	3	1	2	1	1
Mean	4	7.5	4	7.5	3	4.5	3	5	2	3.5	1	3.5

Yield differential of each seed source grown in the location of its origin relative to the best performing seed source at that location



Top performing seed source at each location (t ha^{-1})

	09 L1	09 L2	09 L3	10 L1	10 L2	10 L4
PAN 1454R	SS-L2 3.176	SS-L4 4.464	SS-L4 2.082	SS-L2 1.457	SS-L1 3.949	SS-L1 1.374
A5409RG	SS-L3 3.068	SS-L3 4.270	SS-L1 1.858	SS-L3 1.712	SS-L2 3.439	SS-L4 3.386
Mean performance of both cultivars	SS-L3 3.096 (+0.044 NS > SS-L2)	SS-L4 4.288 (+0.069 NS > SS-L3)	SS-L4 1.922 (+0.126 NS > SS-L3)	SS-L3 1.570 (+0.045 NS > SS-L2)	SS-L1 3.465 (+0.167 NS > SS-L2)	SS-L4 2.321 (+0.165 NS > SS-L1)

General conclusions for acclimatisation:

- In terms of final yield, performance of seed in its location of origin was generally negative relative to the best performing seed source
- Seed was more likely to perform poorly in its location of origin than other locations
- In only one instance, did acclimatisation appear to have occurred for seed grown at its location of origin

Testing the hypothesis of consistent, top performance from a seed source

If performance was driven by the best seed quality then the following (purely hypothetical) ranking within a season could be expected:

		Seed Origin			
		SS-L1	SS-L2	SS-L3	SS-L4
Trial Location	L1		1?		
	L2		2?		
	L3 (‘09 only)		2?		
	L4 (‘10 only)		1?		
			Mean 1		

The following trends presented from the trial data:

Within location ranks for performance of seed source meaned across cultivars

	'09/10 trials					'10/11 trials				
	SS-L1	SS-L2	SS-L3	SS-L4	Mean	SS-L1	SS-L2	SS-L3	SS-L4	Mean
L1	4 2.607	2 3.052	1 3.096	3 2.805	2 2.890	3 1.407	2 1.525	1 1.570	4 1.299	3 1.450
L2	3 4.108	4 3.906	2 4.219	1 4.288	1 4.130	1 3.465	2 3.298	4 3.012	3 3.091	1 3.216
L3	2 1.889	4 1.665	3 1.796	1 1.922	3 1.818					
L4						2 2.156	4 1.717	3 1.947	1 2.321	2 2.035

Within cultivar ranks for performance of seed source meaned across locations

	’09/10 trials				’10/11 trials			
	SS-L1	SS-L2	SS-L3	SS-L4	SS-L1	SS-L2	SS-L3	SS-L4
PAN 1454R	4 2.829	3 2.943	2 3.094	1 3.144	1 2.213	4 1.806	2 1.983	3 1.949
A5409RG	2 2.907	4 2.806	1 2.981	3 2.866	3 2.472	1 2.554	4 2.369	2 2.524
Mean of both cultivars	4 2.868	3 2.874	1 3.037	2 3.005	1 2.343	3 2.180	4 2.176	2 2.237

General conclusions for seed source:

- Within seasons, the mean performance of the cultivars across locations was dependent on seed source i.e. the consistency of performance of the cultivars within each season was affected by seed origin
- Put another way, the cultivars were unstable in terms of their seed quality and it may be argued that selection practiced for stability of seed quality will improve final yield stability

- Within and across seasons, no single seed source was consistently superior for either cultivar across the locations
- Meaned across the cultivars and locations, no single seed source was top performing in both seasons

Future research

- Conduct an expanded study involving more cultivars and trial locations
- Study/quantify maternal and progeny genetic and epigenetic factors to better understand the underlying causes of GXE interactions that influence seed performance in soybean at different locations over seasons
- Hopefully none of the trials fail!

Interpretation of GxE interactions

- Plant breeders and agronomists evaluate the effects of GXE on in/stability of genotypes but the underlying causes are not well understood
- Genotype x Environment interaction may be due to a series of complex sub-interactions, and here are just a few to consider in relation to the genetic and epigenetic factors (mentioned in the Introduction) that affect seed quality and subsequent crop performance:

- Maternal Genotype x Maternal Environment
- (Maternal Genotype x Maternal Environment) X Progeny (embryo) Genotype
- (Maternal Genotype x Maternal Environment) X (Progeny Genotype x Maternal Environment)
- (Maternal Genotype x Maternal Environment) X (Progeny Genotype x Progeny Environment)
- (Maternal Genotype x Maternal Environment) X ((Progeny Genotype x Maternal Environment) x Progeny Environment)
- Progeny Genotype x Progeny Environment?!


THANK YOU FOR YOUR ATTENTION
QUESTIONS?