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Project leader:	Dr Kerry Maguire, PGRO
Report:	Annual report, January 2015
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Location of project:	Processors and Growers Research Organisation, The Research Station, Great North Road, Thornhaugh, Peterborough, PE8 6HJ. Fen Peas Field sites as detailed in the method section
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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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GROWER SUMMARY

Headline

The application of fertilisers at drilling has the potential to increase yields of vining peas in some scenarios.

Background

There has been increasing interest in the application of fertilisers to peas at drilling. Drilling applications allow nutrients to become available to the seedling when it is actively growing and before the plant roots have exploited soil reserves. Some 'starter' nutrient products contain low amounts of nitrogen. There are no recommendations for nitrogen for peas in RB209 and it is detrimental to the formation of root nodules. This study used field scale plots (approximately two hectares per plot) to study the impact of two fertilisers on vining peas drilled at three different times.

Summary

Primary Phosphate (P) (containing nitrogen) and straight P were applied with the seed at drilling, at three sites. Three rates of each fertiliser were used. Each plot was approximately two hectares and, aside from the starter fertiliser, the plots were treated as in the same way as the commercial crop. Each site was drilled at a different time. Drilling began 28th March 2014 and concluded on 7th May 2014. The sites and the drilling times were chosen to fit into the commercial vining pea drilling programme. During the growing season soil samples were taken for soil nutrient analysis and rhizobial counts. The plants were sampled and the above and below ground plant biomass measured and yield taken. Results were mixed. This was partially due to the detrimental effects of root rot on the early drilling. However, the application of fertiliser increased yield at the mid and late drilled sites. These sites also had increased plant mass as a result of the applications. These trials will be repeated in 2015 to confirm the results obtained in 2014.

Financial Benefits

Results from the first year of trials are inconclusive of financial benefits.

Action Points

Action points have yet to be identified.

SCIENCE SECTION

Introduction

Vining peas do not require the addition of nitrogen fertiliser to the crop. They rely on the symbiotic relationship with rhizobia to provide nitrogen to the plant which is vital for growth and yield. This results in an increase in soil nitrogen for the subsequent crop. Rhizobia are soil dwelling bacteria and in the presence of their host, form root nodules and fix atmospheric nitrogen in a form the plant can use. Therefore a healthy soil and a good root system are essential for nodulation and nitrogen fixation. Phosphorous promotes good root growth and is essential for root nodulation to occur. In addition to this, phosphorous is also required for nitrogen fixation. However phosphorous can be a pollutant and applications need to be targeted to when they can be best utilised by the crop. Low soil indices of P have been demonstrated to result in pea plants with reduced vigour and yield (Project FV 380). Granular starter fertilisers are a good source of phosphorous and are delivered to the seedling at drilling. However some of these also contain nitrogen. Nitrogen is not applied to peas and is believed to be detrimental to the formation of nodules.

This project investigates at the effect of applying phosphate close to the seed in the form of granular fertilisers with and without nitrogen.

Materials and methods

Three field trials were established (Table 1). These were drilled using commercial equipment and the fertiliser granules were applied at the time of drilling. The early site was drilled on 28/3/2014 using the variety Novella, the mid site was drilled on 9/4/2014 using the variety Geneva and the final site was a late drilling (7/5/2014) of Kenobi. Each plot was approximately two hectares in size and was treated as a commercial crop, other than the application of starter fertiliser.

Table 1 Field trial site details.

Site	Grower	OS ref	Drill time		Variety
Slate House Farm	G. H. Emmersons	TF2843	28/03/2014	Early	Novella
Fosdyke	J Ward and Sons	TF3634	09/04/2014	Mid	Geneva
Boston	R. G. Farms	TF3147	07/05/2014	Late	Kenobi

Two products were evaluated (Table 2). These were applied at drilling at three rates (Table 3). At the late drilled site the P was applied at lower rates.

Table 2. The formulations of the two products tested.

Treatment	Formulation
P	45% Phosphate, 3% Magnesium and 0.5% Copper
Primary P	Nitrogen 10%, Phosphorus 40%, Sulphur 11%, Magnesium 2%, Zinc 2%

Table 3. Treatments and rates applied (P* rates applied at the late drilled site only)

Treatment	Rate (kg ha^{-1})	P_2O_5 (kg ha^{-1})	N (kg ha^{-1})
Primary P	7.5	3	0.75
Primary P	10	4	1
Primary P	12.5	5	1.25
P	7.5	3.375	0
P	10	4.5	0
P	12.5	5.625	0
Untreated	0	0	0
P*	P 4.5	2.025	0
P*	P. 7	3.15	0
P*	P. 8.5	3.85	0

Soil Sampling

All soil sampling was carried out in a 'W' shape across the plot (Table 4). The soil nutrient analysis was carried out by Hill Court Farm Research.

Table 4. The times of the soil and plant samples.

Sampling times	Rhizobia	Standard soil analysis	Soil Mineral N (SMN)/(cm)			Plant and root sample
			0-30	30-60	60-90	
Prior to drilling	yes	yes	yes	yes	yes	n/a
First Bud	yes	n/a	n/a	n/a	n/a	yes
After harvest	yes	yes	yes	yes	yes	n/a

Soil sampling for Rhizobia analysis: The top 3 cm of soil was discarded. A soil sample was taken using a soil corer to a depth of 25 cm (within the pea root zone). The cores taken from each plot were mixed and placed in the fridge at 5ºC.

Standard soil analysis: The top 3 cm of soil was discarded. A soil sample was taken using a soil corer to a depth of 15 cm. The cores taken from each plot were mixed and 250 g was analysed.

SMN analysis: Three soil cores were taken at each sample point at depths of 0-30 cm, 30-60 cm and 60- 90 cm. A composite was made of the corers from each depth and 250 g was analysed.

Soil Analysis Methods

Available P: extraction in 0.5M $NaHCO_3$, pH 8.5 for 30 min (Olsen P).

Available K and Mg: extraction in 1M NH_4NO_3 for 30 min

pH: measurement in deionised H_2O.

Available N (Nitrate-N & Ammonium-N): extraction in 1 M KCl for 1 hour.

Soil Textures: Sandy Loam (SL); Loamy Sand (LS); Silty Clay Loam (ZCL); Sandy Clay Loam (SCL); Clay Loam (CL); Silty Clay (ZC); Sandy Clay (SC); Clay (C); Loam (L).

Plant Sampling

At first bud the plot was divided into four replicates. Twenty five plants were randomly taken from each replicate. The plants were separated from their neighbours and the entire plants including as many roots as possible were collected.

The roots were removed from the above ground material. Both portions were dried to constant mass to measure the growth of the plants.

Rhizobia enumeration

The plant infection method of most probable number of Rhizobia detailed by Somasegaren and Hoben (1994) was used. The soil samples taken from Fosdyke (Table 1) prior to drilling were tested against a control sample using 10 dilutions from 10^{-1} to 10^{-10}, 1ml aliquots and 4 replicates. Peas were placed onto various media in test tubes and infected with soil solutions. This method was used to determine the number of viable, infective rhizobia cells per gram of soil.

6 techniques were used as follows:

- 100% tap water agar media in test tubes, foil-wrapped to prevent light exposure;
- 100% tap water agar media in test tubes exposed to light;
- 75% technical agar media with nutrient solution in test tubes, foil-wrapped to prevent light exposure;

- 85% tap water agar media in test tubes exposed to light;
- 85% tap water agar media with nutrient solution in test tubes exposed to light;
- 75% tap water agar media in test tubes partially exposed to light.

Results

Figure 1. Drilling the trial (Photo courtesy of Fen Peas)

All three sites produced a good crop of peas although the site of the early drilling had an area of foot rot which was distributed across the field.

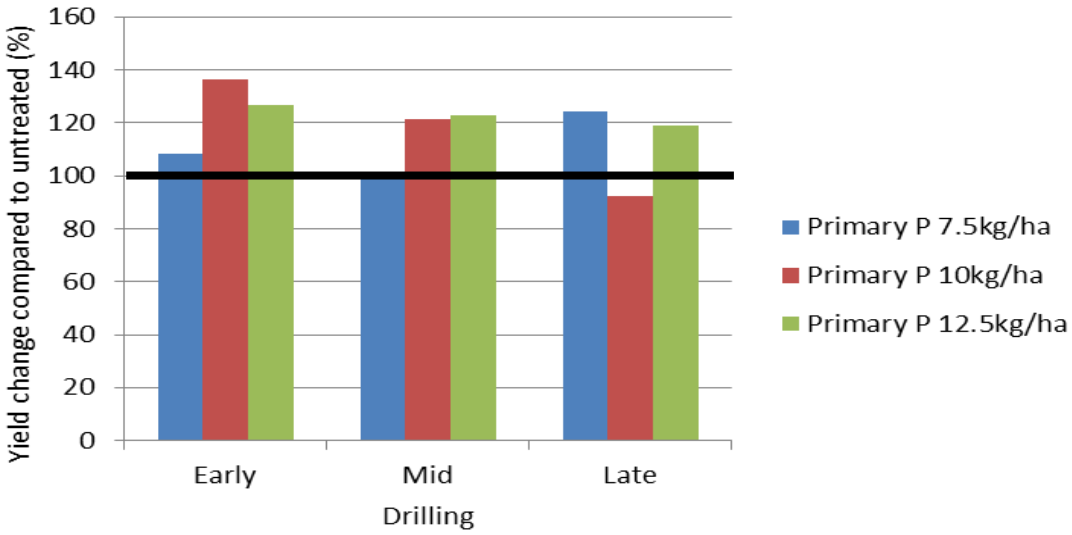

Figure 2. The effect of Primary P on the pea yield expressed as a percentage difference from the untreated (100%).

Application of Primary P resulted in a yield increase across all application rates at the three drilling times except for the application of 10kg/ha at the late drilling period (Fig. 2). This did not follow the trend seen with the rest of the treatments.

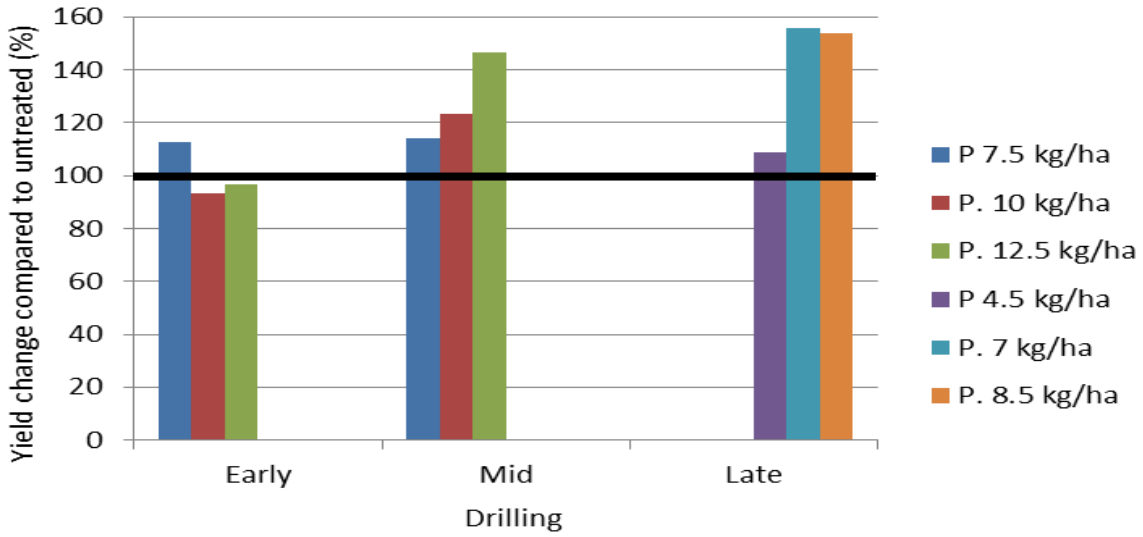

Figure 3. The effect of P fertiliser on the pea yield expressed as a percentage difference from the untreated (100%).

The application of P increased the yields at the mid and late drillings but the results for the early drilling were mixed. This may be the result of root rots affecting plant growth and yield.

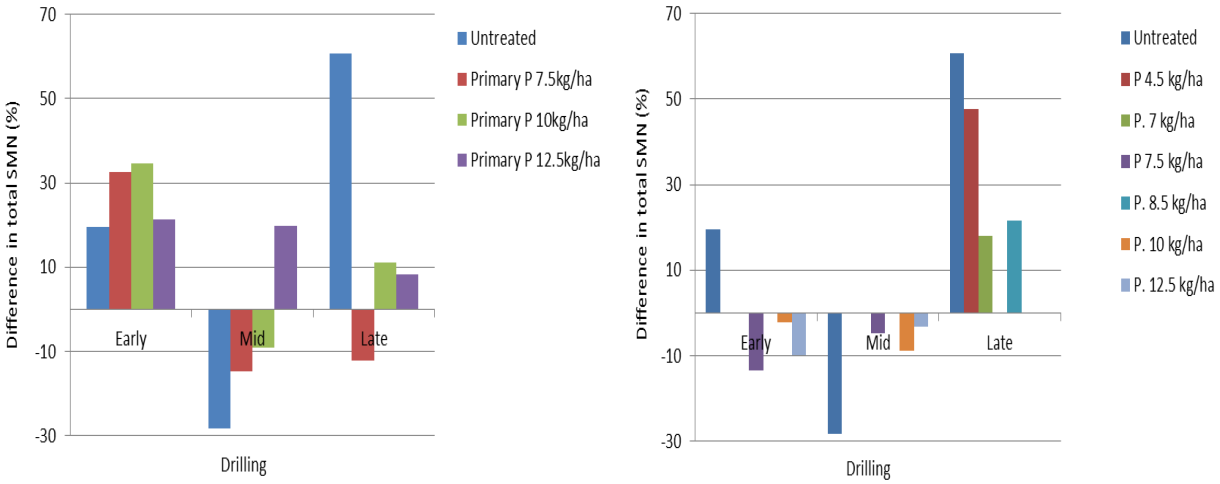

Figure 4. The percentage difference in the total measured Soil Mineral N between treatments and at the different sites compared to the pre-drilling measured SMN.

The late drilled site had the greatest amount of soil mineral nitrogen left after the crop was harvested (Fig 4).

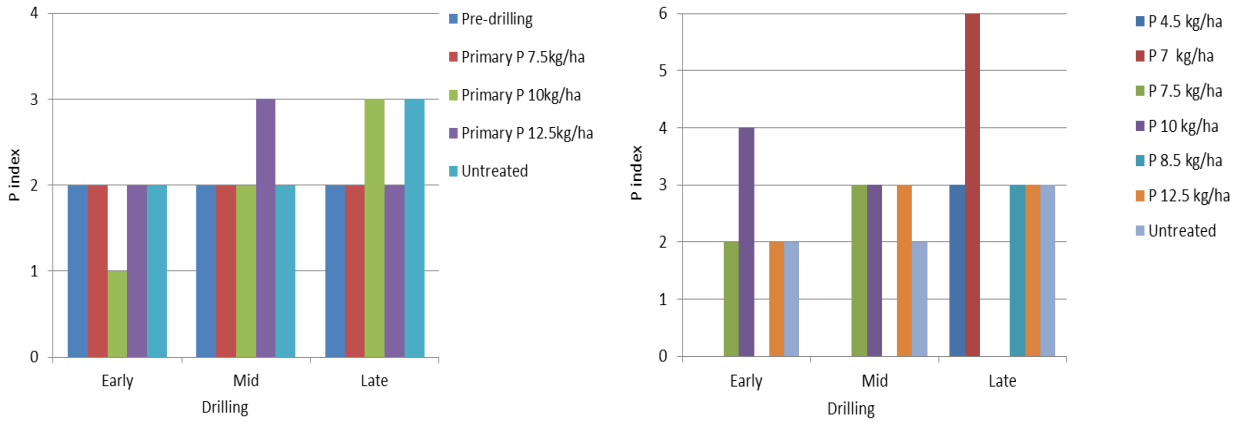

Figure 5. P index before the trials were drilled and at the end of the season

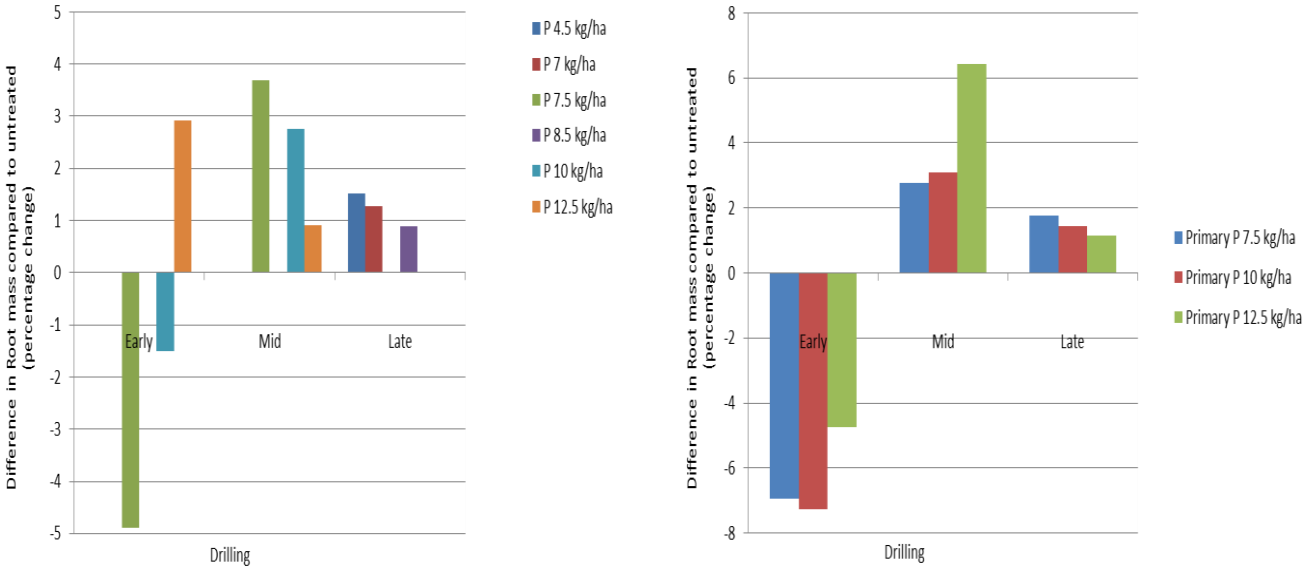

Figure 6. The percentage difference in root mass for each treatment compared to the untreated crop. A significant (P=0.007) increase in root mass with the Primary P 10kg/ha and P 7.5 kg/ha was observed at the mid drilling.

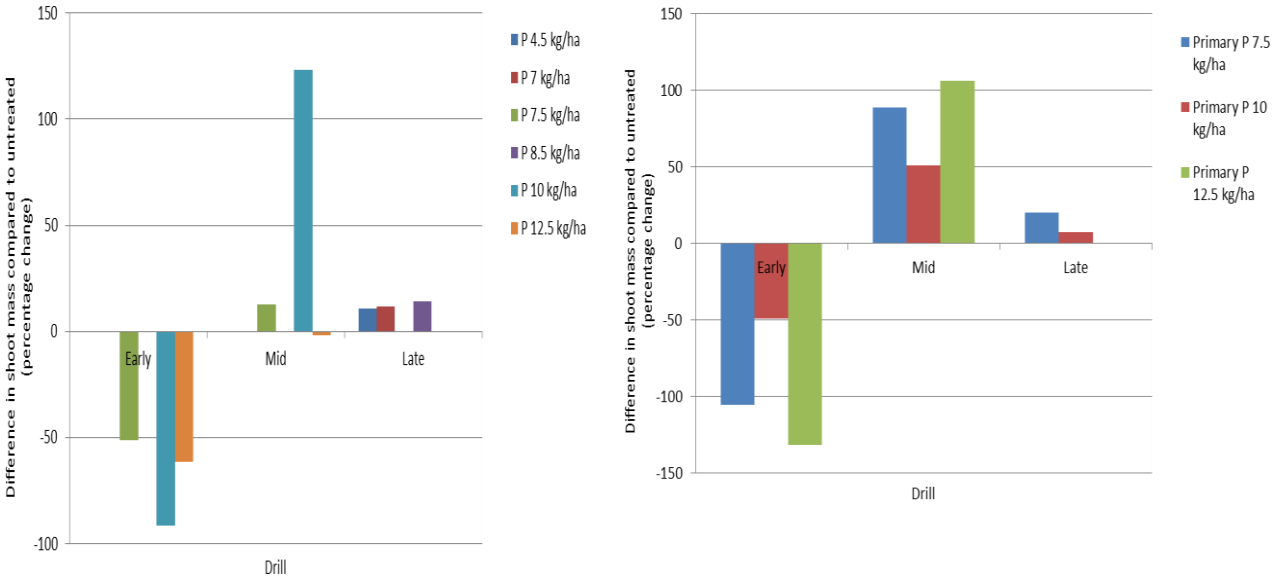

Figure 7. The percentage difference in shoot mass for each treatment compared to the untreated crop. A significant (P=0.01) increase in shoot mass over the untreated was observed with the Primary P 7 and 10kg/ha and P 10 kg/ha at the mid drilling.

Root and shoot mass increased following application of both Primary P and P in the mid and late drillings (Fig 6 and 7). This increase was not seen in the early drilling.

Table 5. Summary of determination of viable and infective rhizobia for the Fosdyke pre-drilling soil sample compared to a control sample, using the plant infection method (Most Probable Number (MPN) - Somasegaren and Hoben (1994)).

Sample	Technique	Number of nodules found per plant	MPN (rhizobia) – cells/ g soil
Fosdyke	100% tap water agar in test tubes, foil wrapped to prevent light exposure	0	0
Control	100% tap water agar in test tubes, foil wrapped to prevent light exposure	1 at 10¯10 dilution (discard)	Discard
Fosdyke	100% tap water agar in test tubes exposed to light	0	0
Control	100% tap water agar in test tubes exposed to light	0	0
Fosdyke	75% technical agar with nutrient solution in	0	0

	test tubes, foil-wrapped to prevent light exposure		
Control	75% technical agar with nutrient solution in test tubes, foil-wrapped to prevent light exposure	6 at 10^{-4} dilution	0.58
Fosdyke	85% tap water agar in test tubes exposed to light	0	0
Control	85% tap water agar in test tubes exposed to light	0	0
Fosdyke	85% tap water agar with nutrient solution in test tubes exposed to light	0	0
Control	85% tap water agar with nutrient solution in test tubes exposed to light	0	0
Fosdyke	75% tap water agar in test tubes partially exposed to light	0	0
Control	75% tap water agar in test tubes partially exposed to light	0	0

Discussion

The investigation aimed to evaluate the effect of Primary P and P applied at drilling on the pea crop and to monitor soil nutrient status.

The addition of fertiliser at the time of drilling did not adversely affect the crop and in general there was an increase in yield where the fertiliser was added. The greatest yield increases were seen with the application of P at the mid and late drillings. This is particularly interesting as the late site had less P applied than the mid sites.

The root and shoot biomass measurements carried out in the growing season showed an increase in plant biomass in the treated plots. The greatest increase in plant biomass was in the middle drilling. The later drilling was drilled in more favourable conditions (warmer soils) and may not have benefitted as much from the fertiliser application. However at harvest the late drilled site had a greater yield increase in the plots with the P application. This yield increase was greater than that seen in the mid drilled plots. Unfortunately the early drilled plots were infected with root rots. This resulted in a mixed response to the fertiliser applications. The yield responses must be treated with caution as they represent a single year of unreplicated trials. In addition the untreated yield values also include the field headland areas which may further depress yield values. Trials will be repeated in 2015 with

the addition of small replicated yield assessments within the large plots. The Untreated yield will be taken from a plot alongside the treated area, avoiding the headland. This will provide a more reliable untreated yield value.

Rhizobia enumeration is in the early stages of determination but results indicate that the plant infection test works. Further MPN tests are being undertaken on soil samples collected in 2014, and will be undertaken on soil samples collected in 2015.

Conclusions

Analysis of the data from one year's harvest concludes the applications do not have a detrimental effect on the crop. The treatments did increase yield. The second season of trials will provide firm conclusions on the application of fertilisers to peas at drilling. The data from the Rhizobia enumeration will help to conclude the effect of the treatments on Rhizobia numbers.

Knowledge and Technology Transfer

PGRO Open day 2014 (Oral and Poster presentation)

Cereals 2014 (Poster presentation)

VAA Meeting November 2014 (Oral presentation)

Holbeach Marsh Pea Growers Technical Meeting 2014 (Oral presentation)

Warwick Crop Centre Seminar November 2014 (Oral presentation)

The Pulse Magazine Spring 2014 (Article)

PGRO Staff Away day 2014 (Oral presentation)

Bruce Farms Technical meeting 2014 (Oral presentation)

References

Somasegaren, P. and Hoben, H. (1994) Handbook for Rhizobia Chapter 1 General Microbiology of Rhizobia pp1-79.

Appendix 1 Nutrient details for each site

				28/03/2014							01/08/2014						
					Phosphorus (P)		Potassium (K)		Magnesium (Mg)			Phosphorus (P)		Potassium (K)		Magnesium (Mg)	
Farm GH	**Variety**	**Drilled**	**Treatment**	**pH**	**mg/l**	**Index**	**mg/l**	**Index**	**mg/l**	**Index**	**pH**	**mg/l**	**Index**	**mg/l**	**Index**	**mg/l**	**Index**
Emerson	**Novella**	**28/03/2014**	Primary P 7.5kg/ha								7.71	18	2	317	3	185	4
			Primary P 10kg/ha								7.56	15	1	290	3	253	5
			Primary P 12.5kg/ha								7.74	24	2	335	3	288	5
			P 7.5 kg/ha								7.76	21	2	301	3	297	5
			P. 10 kg/ha								7.76	54	4	251	3	219	4
			P. 12.5 kg/ha								7.87	24	2	295	3	207	4
			Untreated	7.5	21	2	176	-2	217	4	7.81	25	2	308	3	297	5

				28/03/2014							01/08/2014						
					Phosphorus (P)		Potassium (K)		Magnesium (Mg)			Phosphorus (P)		Potassium (K)		Magnesium (Mg)	
Farm	**Variety**	**Drilled**	**Treatment**	**pH**	**mg/l**	**Index**	**mg/l**	**Index**	**mg/l**	**Index**	**pH**	**mg/l**	**Index**	**mg/l**	**Index**	**mg/l**	**Index**
J Ward	**Geneva**	**09/04/2014**	Primary P 7.5kg/ha								8.22	24	2	430	4	150	3
			Primary P 10kg/ha								8.22	19	2	374	3	139	3
			Primary P 12.5kg/ha								8.25	26	3	504	4	165	3
			P 7.5 kg/ha								8.24	30	3	568	4	182	4
			P. 10 kg/ha								8.09	27	3	509	4	152	3
			P. 12.5 kg/ha								8.22	33	3	532	4	166	3
			Untreated	8.2	24	2	450	4	174	3	8.29	21	2	621	5	176	4

Farm	Variety	Drilled	Treatment	28/03/2014							01/08/2014						
				pH	Phosphorus (P)		Potassium (K)		Magnesium (Mg)		pH	Phosphorus (P)		Potassium (K)		Magnesium (Mg)	
					mg/l	Index	mg/l	Index	mg/l	Index		mg/l	Index	mg/l	Index	mg/l	Index
RG Farms	**Kenobi**	**07/05/2014**	Primary P 7.5kg/ha								7.21	24	2	196	2+	313	5
			Primary P 10kg/ha								6.8	30	3	214	2+	262	5
			Primary P 12.5kg/ha								7.52	25	2	166	-2	232	4
			P 4.5 kg/ha								7.49	44	3	244	3	229	4
			P. 7 kg/ha								7.57	107	6	254	3	191	4
			P. 8.5 kg/ha								7.85	34	3	200	2+	180	4
			Untreated	7.9	18	2	344	3	283	5	7.55	38	3	271	3	176	4

Appendix 2 Nitrogen details for each site

R.G. Farms,
Cowbridge

Date of sample	Treatments	Depth (cm)	Soil type	Nitrate - N (kg/ha)	Ammonium-N (kg/ha)	Available N (kg/ha)	PMN (kg/ha)	OM (%)	tN (%)
28/03/2014	Field	0-30	ZCL	25	8.6	33.6	177.5	3.29	0.162
	Field	30-60	ZCL	26.1	4.4	30.5			
	Field	60-90	ZL	31.4	2.7	34.1			
31/07/2014	Primary P 7.5kg/ha	0-30	ZCL	24.1	7.9	32	110.8	3.51	0.185
	Primary P 7.5kg/ha	30-60	ZL	24.6	0.9	25.5			
	Primary P 7.5kg/ha	60-90	ZL	28.8	0	28.8			
	Primary P 10kg/ha	0-30	ZCL	26.5	9	35.5	54	3.48	0.189
	Primary P 10kg/ha	30-60	ZL	33.9	3.8	37.8			
	Primary P 10kg/ha	60-90	ZL	35.8	0	35.8			
	Primary P 12.5kg/ha	0-30	ZCL	33.2	13	46.2	98.5	3.15	0.167
	Primary P 12.5kg/ha	30-60	ZL	28.3	0	28.3			
	Primary P 12.5kg/ha	60-90	ZL	31.8	0	31.8			
	P 4.5 kg/ha	0-30	ZCL	25.8	11.1	36.9	119.3	3.78	0.179
	P 4.5 kg/ha	30-60	ZL	43.5	7.6	51.1			
	P 4.5 kg/ha	60-90	ZL	56.9	0	56.9			
	P. 7 kg/ha	0-30	ZCL	25.2	9.1	34.4	114.7	3.54	0.167
	P. 7 kg/ha	30-60	ZL	35.8	6.9	42.7			
	P. 7 kg/ha	60-90	ZL	38.9	0	38.9			
	P. 8.5 kg/ha	0-30	ZCL	24.1	10.4	34.5	156.7	3.25	0.158
	P. 8.5 kg/ha	30-60	ZL	31.7	3.5	35.2			
	P. 8.5 kg/ha	60-90	ZL	49.8	0	49.8			
	Untreated	0-30	ZCL	23.3	13.1	36.3	164.1	3.98	0.188
	Untreated	30-60	ZL	22.8	5.6	28.4			
	Untreated	60-90	ZL	30.6	62.6	93.1			

G. H. Emmerson Slate House Farm

Date of sample	Treatment	Depth (cm)	Soil type	Nitrate - N (kg/ha)	Ammonium-N (kg/ha)	Available N (kg/ha)	PMN (kg/ha)	OM (%)	tN (%)
28/03/2014	Field	0-30	ZCL	16.7	6.1	22.7	113.4	3.18	0.136
	Field	30-60	ZCL	8.8	3	11.8			
	Field	60-90	ZCL	10.1	2.3	12.4			
18/07/2014	Primary P 7.5kg/ha	0-30	ZCL	22.9	1.9	24.7	57.8	2.63	0.199
	Primary P 7.5kg/ha	30-60	ZL	20.7	0	20.7			
	Primary P 7.5kg/ha	60-90	ZL	16.8	0	16.8			
	Primary P 10kg/ha	0-30	ZCL	20	0.3	20.3	70.9	2.66	0.222
	Primary P 10kg/ha	30-60	ZL	22.4	0	22.4			
	Primary P 10kg/ha	60-90	ZL	20.4	0	20.4			
	Primary P 12.5kg/ha	0-30	ZCL	26.6	0	26.6	141.8	2.66	0.19
	Primary P 12.5kg/ha	30-60	ZL	13.3	0	13.3			
	Primary P 12.5kg/ha	60-90	ZL	17	0	17			
	P 7.5 kg/ha	0-30	ZCL	13.7	0.1	13.9	68.8	3.17	0.181
	P 7.5 kg/ha	30-60	ZL	14.1	0	14.1			
	P 7.5 kg/ha	60-90	ZL	12.5	0	12.6			
	P. 10 kg/ha	0-30	ZCL	17.1	0	17.1	70.7	2.74	0.171
	P. 10 kg/ha	30-60	ZL	17.9	0	17.9			
	P. 10 kg/ha	60-90	ZL	10.9	0	10.9			
	P. 12.5 kg/ha	0-30	ZCL	15.6	0.8	16.4	58.3	2.79	0.163
	P. 12.5 kg/ha	30-60	ZL	12.5	0	12.5			
	P. 12.5 kg/ha	60-90	ZL	13.4	0	13.4			
	Untreated	0-30	ZCL	18.5	0	18.5	60.7	3.09	0.17
	Untreated	30-60	ZL	21.2	0	21.2			
	Untreated	60-90	ZL	16.4	0	16.4			

J. Ward and Sons Fosdyke Bridge

Date of sample		Depth (cm)	Soil type	Nitrate - N (kg/ha)	Ammonium-N (kg/ha)	Available N (kg/ha)	PMN (kg/ha)	OM (%)	tN (%)
28/03/2014	Field	0-30	CL	19.1	10.7	29.7	96.5	3.43	0.147
	Field	30-60	ZCL	20.4	3.2	23.6			
	Field	60-90	ZL	30.1	2.2	32.2			
18/07/2014	Primary P 7.5kg/ha	0-30	ZCL	17.5	1	18.5	114.7	3.23	0.156
	Primary P 7.5kg/ha	30-60	ZL	21.6	0	21.6			
	Primary P 7.5kg/ha	60-90	ZL	32.9	0	32.9			
	Primary P 10kg/ha	0-30	ZCL	19.5	2.1	21.5	90.2	3.43	0.172
	Primary P 10kg/ha	30-60	ZL	22.1	0	22.1			
	Primary P 10kg/ha	60-90	ZL	34.2	0	34.2			
	Primary P 12.5kg/ha	0-30	ZCL	21.9	1.8	23.8	78.9	3.42	0.172
	Primary P 12.5kg/ha	30-60	ZL	34.2	6.2	40.3			
	Primary P 12.5kg/ha	60-90	ZL	38.3	0	38.3			
	P 7.5 kg/ha	0-30	ZCL	13.5	1.7	15.2	81.1	3.14	0.154
	P 7.5 kg/ha	30-60	ZL	25.7	1.6	27.2			
	P 7.5 kg/ha	60-90	ZL	36.8	2.2	39			
	P. 10 kg/ha	0-30	ZCL	22.3	1.3	23.5	94.9	3.24	0.153
	P. 10 kg/ha	30-60	ZL	23.1	0.1	23.1			
	P. 10 kg/ha	60-90	ZL	30.7	0.7	31.4			
	P. 12.5 kg/ha	0-30	ZCL	15.3	2.5	17.7	82.4	2.86	0.152
	P. 12.5 kg/ha	30-60	ZL	23.1	0.3	23.4			
	P. 12.5 kg/ha	60-90	ZL	41.7	0	41.7			
	Untreated	0-30	ZCL	8.5	6.2	14.7	100.1	2.9	0.153
	Untreated	30-60	ZL	18.3	0.1	18.4			
	Untreated	60-90	ZL	28.3	0	28.3			

