Trial Title: Saxmundham Experimental Site

Centre: Morley (location: Saxmundham, Suffolk) **Trial Code:** WW21-9513 **Variety:** Valerie

Objective: To measure and compare the response to crop and soil from the application of granular and foliar phosphate and potassium based mineral fertilisers, manures and organic amendments.

Background: The Saxmundham Experimental site was started in 1899 and has been managed by various organisations since this time including Rothamsted Research. The site is currently supported through TMAF and the NIAB Morley Long Term Studies (LoTS) initiative. Despite falling out of service in recent years, through the intervention of TMAF, NIAB and local farmers, the long-term experimental work has been resurrected. The 2020 season saw the updating of some treatments to better reflect modern phosphorus management and challenges the industry faces. The trial studies the effects of cumulative application of P and/or K fertilisers (granular and foliar) compared to farmyard manure (FYM) and green waste compost (GWC).The full treatment list and research rational is reported in Table 1. The rotation is based ostensibly on combinable cropping (Table 2). All nitrogen and pesticide inputs are of standard farm practice. Each plot is approximately 40m x 5.5m with four blocks (reps), although treatments are not randomised in each block.

Table 1 Treatment list with description and rationale, new treatments for the 2020-2025 trial program are highlighted *

Treatment (Label)	**Details**	**Rationale**
Untreated (Unt)	No organic or in-organic P or K fertiliser	Untreated control
Cattle FYM (FYM)	Annual applications (25 t ha) of farm yard manure. Have been applied for large proportion of the 120 year trial	Comparing organic P and K sources to mineral fertiliser
Green waste compost + P_2O_5 (GWC) *	Dose to match organic matter returns from 25 t/ha FYM Soil P maintained at index 1 (P_2O_5 dose adjusted for P in compost) Soil K maintained at index 2 (K_2O dose adjusted for K in compost)	By improving soil structure through amendment use can yields be maintained on a P index 1 soil compared to standard (PK) nutrient management?
Folex P (Foliar) *	Repeated foliar applied P treatments (4 in 2021) Folex P supplied by OMEX (14%N, 46% P2O5 w/v) applied at 15 l/ha	With a P index 0 soil how much of a crops phosphate demand can be met through foliar sprays?
P_2O_5 (P)	RB209 recommended dose based on soil P analysis (2019) and estimated off take	Crop response to optimal applications of P mineral fertiliser only
K_2O (K)	RB209 recommended dose based on soil K analysis (2019) and estimated off take	Crop response to optimal applications of K mineral fertiliser only
$P_2O_5 + K_2O$ (PK)	RB209 recommended dose based on soil P and K analysis (2019) and estimated off take	Crop response to optimal applications of P and K mineral fertiliser
$P_2O_5 + K_2O$ (P_LK) *	RB209 recommended dose for maintain P at Index 1 and K at Index 2 based on soil analysis	Crop response to optimal K and low P fertiliser applications. Direct comparison for GWC treatment

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Table 2 rotation

Farm rotation	Historical	2014	2015	2016	2017	2018	2019	2020	2021
	Various	1st WW	2nd WW	W Barley	1st WW	WOSR	1st WW	SW	W Barley

Summary:

In 2021 the Saxmundham site was sown with Winter Barley (cv Valerie) following a sumo non-inversion primary cultivation.

- No increase in yield or measured grain P concentrations was recorded from Foliar P applications compared to untreated or through two years of green waste compost applications
- Maintaining an Index 2 P soil resulted in a 1.4 t/ha yield increase compared to untreated (historically an index 0 or low index 1 P soil)
- Repeated application of FYM over the 120 year trial period have increased soil organic matter by 0.6%
- The higher soil organic matter has increased earthworm numbers and improved soil structure in the FYM plots
- These changes in soil properties are the likely cause of the recorded improved P utilisation and historic yield increases in the FYM plots compared to PK.
- No yield response was seen from plots receiving K fertiliser.

Results

Data collected at plot level was analysed in GENSTAT for ANOVA with a Tukey's post hoc analysis test performed where significant (P=0.05) differences was observed.

Soil nutrients, organic matter and earthworms

Soil phosphorus, potassium and SOM are reported in table 3. All plots where index 2 Mg and soil mineral N measured in the spring was low across the trial (8-24 kgN/ha).

Soil P levels were low (index 1) in treatments receiving no mineral P fertiliser or organic inputs. In 2021 the P_LK and GWC both received mineral P fertiliser to maintain a mid-index 1 soil. Soil analysis suggests they are close to this, rising this year slightly to a very low index 2 soil (Figure 2), maintenance applications will aim to maintain an P index 1 soil. The FYM, P and PK plots can be expected to have sufficient soil P to meet crop demand (index 2). Despite plots not receiving any K fertiliser or amendments (P, Unt, Foliar and GWC) indices are a high index 1 or an index 2-. This is a result of the natural K realising soils.

SOM is not significantly different between any treatments except FYM. Repeated FYM applications over 120 years have increased SOM by 0.6% , compared to Untreated. This is a 16% relative increase, equivalent to about 12 t/ha additional organic matter in top 15cm of soil. The second application of GWC was applied in 2021, with a significant increase in SOM yet to be recorded and will likely take numerous applications.

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Earthworm abundance is higher in the FYM plots, but with large variation. This data set will strengthen over the 5 years of the LoTS program. Visual Evaluation of Soil Structure also recorded improvements in soil structure in the FYM plots compared to the Unt and PK treatments.

Table 3. Topsoil (0-20cm) phosphorus, potassium, organic matter and earthworm population and weight ($1m^2$). Letters identify significant differences between treatments

Trt	P (mg/l)		K (mg/l)		SOM %		Earthworm population	Earthworm weight (g)	VESS
Unt	10.9	a	127.0	abc	3.8	a	5	1.3	2.6
K	12.8	ab	162.5	cd	3.8	a	-	-	
Foliar	12.7	ab	100.8	a	3.9	a	-	-	
GWC	17.3	abc	114.8	ab	4.1	ab	-	-	
PLK	17.4	abc	174.8	d	3.9	a	-	-	
P	21.2	bc	111.6	a	3.9	a	-	-	
PK	25.9	c	157.2	bcd	4.0	a	6	1.4	2.7
FYM	22.1	bc	159.2	bcd	4.4	b	10	3.4	2.1
P Value	<0.001		<0.001		0.003		-	-	-

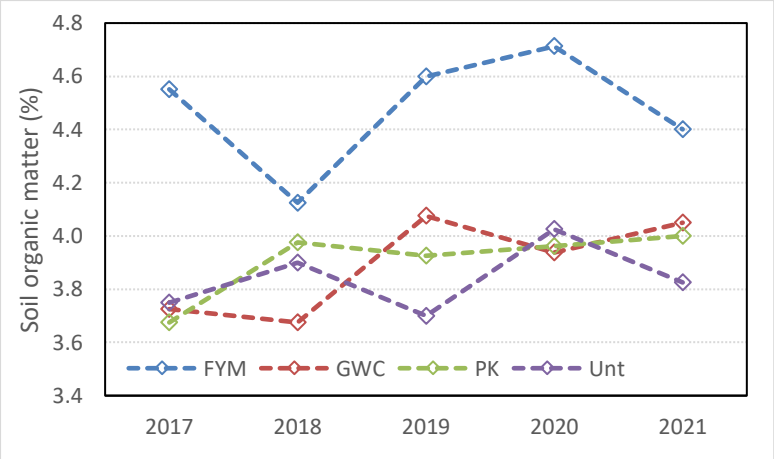

Figure 2 Soil organic matter for selected treatments across years

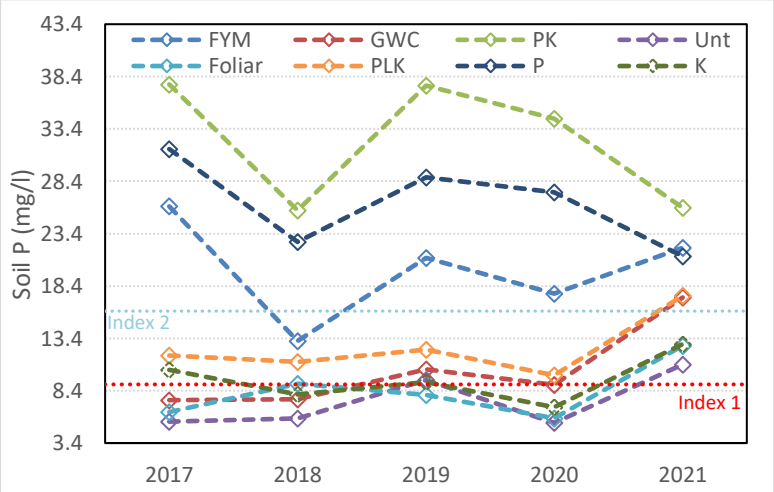

Figure 1 Soil P for all treatments across years

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Crop performance

Table 3 shows plant population, yield, grain P and grain protein results. The FYM plots had the highest plant populations, indicating slightly better establishment, although this is not significant at a 5% confidence interval.

The FYM plots had the highest yields of 10.7 t/ha, a 1.9 t/ha increase over untreated and significantly higher than all treatments not managed at a P Index 2. This was also 0.5 t/ha higher than the PK plots, although not significant, but consistent with previous years.

No yield response was seen from plots receiving K.

The GWC plots saw no significant yield increase compared to P_LK suggesting following two applications of GWC, soil structure has not sufficiently improved to allow for yields to be maintained at a lower soil P index (i.e. Index 1).

The application of Foliar P resulted in no yield increase compared to Unt, suggesting little of the crops P demand was met through foliar P application in 2021.

Table 3 Plant populations (m2), head counts (m2), Green Area Index (GAI), Yield (t ha) and Grain P (mg/kg). letters indicate significant comparisons between treatments

	Plants m^2		**Yield (t ha)**		**Grain P (mg/kg)**		**Grain Protein (%)**	
Unt	107	a	8.8	a	2017	a	11.1	a
K	116	a	8.0	a	2031	a	14.0	b
P_LK	105	a	9.2	ab	2273	ab	11.1	ab
Foliar	111	a	8.7	a	2290	ab	14.0	b
GWC	113	a	9.2	ab	2374	ab	10.8	a
P	116	a	10.2	bc	2718	b	10.7	a
PK	111	a	10.2	bc	3148	c	12.4	ab
FYM	136	a	10.7	c	3297	c	13.0	ab
P value	0.061		<.001		<.001		0.002	

Testing the soil for P tells us the levels of plant available P in the soil. Grain P analysis can tell us if the plant was sufficiently able to access this supply. Currently in cereals a grain P of 0.32% (3200 mg/kg) is considered optimal. When plotted together, soil and grain P can provide an interpretation into a crops P availability and utilisation (Figure 3).

Figure 3 shows that treatments not receiving any soil applied P fertiliser or organic material can be defined as having low soil P and low grain P suggesting insufficient supply and access to P.

Despite slightly higher soil P levels (low index 2) the GWC and P_LK also have bellow optimal grain P concentrations confirming that after two years of compost application we do not see an increase in the plants ability to access a reduced supply of soil P through improved soil structure or biological activity, compared to optimal soil P management.

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The P and PK plots have higher soil P and grain P levels, although grain P levels are slightly below optimum, potentially suggesting despite adequate soil P levels access to this supply is limited by other soil physical or chemical properties.

The FYM treatment is the only treatment inside the boundaries of optimal soil P and optimum grain P. In 2021 FYM yielded 0.5 t/ha higher than the P and PK in and has historically yielded significantly higher than the PK plots. Supporting the conclusion that through a 0.6% increase in soil organic matter, and subsequent increased earthworm abundance and improved soil structure, nutrients and water are likely more readily accessed in the FYM plots increasing crop yields.

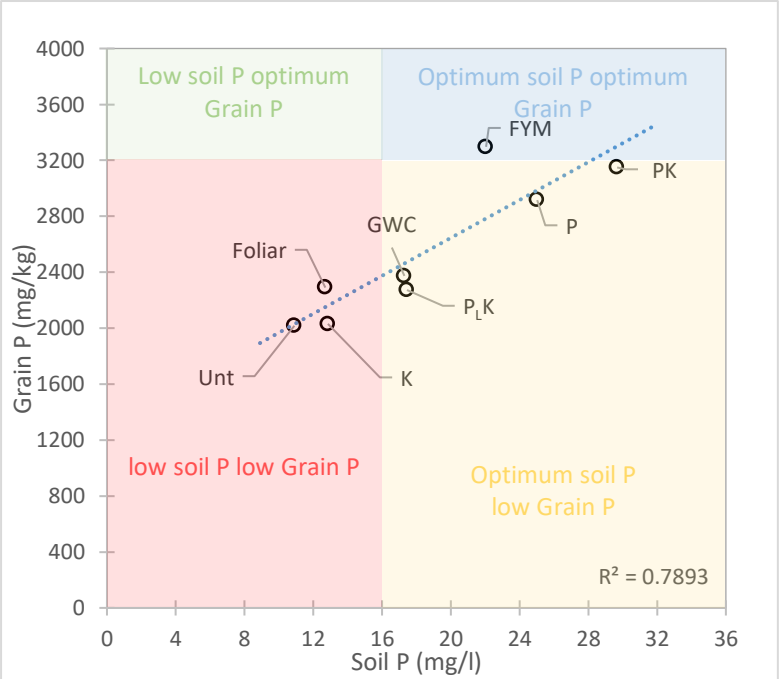

Figure 3 treatment mean Soil P compared to Grain P.

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Field details & overall applications to crop

Crop:	Winter Barley
Trial ID:	WW21-9513
Location: Name and 6 fig grid ref	Saxmundham
Variety:	Valerie
Seed rate:	150 kg/ha
Soil type:	Clay loam
Previous crop:	Spring Wheat
Drill date:	15/09/2020
Harvest date:	29/07/2021
Drilled plot size:	40m x 5.5m (farm crop)
Harvested plot size:	Approx. 2mx15m
Replicates:	4 (not randomised)

Input type	Product	Product rate	Date
Herbicide	Anthem	3.0 l	23/09/2020
	Liberator	0.6 l	
Fertiliser	N	70kg	22/02/2021
	N	45kg	26/02/2021
	N	66kg	01/03/2021
	N	45kg	20/04/2021
	Manganese	3 l	27/02/2021
	Manganese	3 l	22/04/2021
Fungicide	Siltra	0.6 l	22/04/2021
	Comet	0.4 l	
	CCC	2.0 l	
	Revysol	0.6 l	23/05/2021
PGR	Terpal	1 l	
Adjuvant	Activator 90	0.05l	27/02/2021
	Activator 90	0.05l	06/05/2021

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