



**Capabilities of Aquagrain water holding capacity and its
nutrient contents in increasing crop yield in East Anglian
sandy soil**

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1- Objective

The objective of the trial is to assess if the application of Aquagrain increases soil water retention and its nutrient properties also have a positive effect on the growing of crops in very sandy soil.

2- Introduction

The East of England is an important agricultural region with a farmed area of about 1.38 million hectares (Table 1). More than a quarter of this is used for cereal production. However, yields are slightly lower than the national average (Defra, 2011a). This is also one of the driest regions in England, which may be a partial explanation for the lower yield.

Studies by the university of Cranfield in 2015 suggest that the yield benefit would justify supplemental irrigation by farmers, but it comes with a lot of ifs. Irrigation of cereals is only commercially viable if farmers have unused irrigation equipment and unused summer water. Usually irrigation of higher-value field vegetable crops later in the season would normally take precedence.

Table 1

Wheat production summary statistics for England and the East of England for 2011.

Indicator	England	East of England	East of England/ England (%)
Farmed area ($\times 10^6$ ha)*	8.89	1.38	15.5
Wheat area ($\times 10^6$ ha)*	1.79	0.50	28.0
Wheat yield (t ha^{-1})	7.73	7.21	93.3
Wheat production (Mt)	13.8	3.6	26.1
Wheat output (million £)	1984.64	573.51	28.9
Total crop output (million £)	7724.42	1979.58	25.6

(Source: Defra, 2011a)

* Area data relate to 2010.

Aquagrain could solve low yield issue in East Anglia and help crops to cope with drought conditions in this region. Aquagrain is a unique, organic-based, biodegradable soil improver which can absorb up to 30 times its mass in water, enabling crops to grow in arid lands and free-draining substrates, using a fraction of the water normally required. Aquagrain capability in delaying permanent wilt point make it a perfect product for rainfed crops (see www.aquagrain.co.uk). With its nitrogen, phosphorous, potassium (NPK), Ca, Mg, S, trace element such as zinc, manganese and copper (table 2) and amino acid, Aquagrain can provide plants with all the nutrients they need to grow.

Field trails in Suffolk were set up to put this idea to the test.

Table 2- Chemical analysis of Aquagrain

No.	Element	Expressed in form of	quantity
1.	N	N	5.5% m/m
2.	P	P ₂ O ₅	6.6% m/m
3.	K	K ₂ O	4.2% m/m
4.	Ca	CaO	7.8% m/m
5.	Mg	MgO	1.7% m/m
6.	S	SO ₃	1.1% m/m
7.	Total organic C	C	6.9% m/m
8.	As	As	1.1 mg/kg
9.	Cd	Cd	<0.1 mg/kg
10.	Co	Co	<0.1 mg/kg
11.	Cr	Cr	<0.1 mg/kg
12.	Cu	Cu	15 mg/kg
13.	Mn	Mn	13 mg/kg
14.	Pb	Pb	3.4 mg/kg
15.	Hg	Hg	<0.1 mg/kg
16.	Mo	Mo	<0.1 mg/kg
17.	Ni	Ni	0.5 mg/kg
18.	Se	Se	<4 mg/kg
19.	Zn	Zn	25 mg/kg

3- Winter Barley Trial Design

The trial was carried out on the Elveden Estate near Thetford in Norfolk (map 1). The winter barley variety Flagon was used. The trial design had winter barley growing under 3 different treatments.

- **Farm Standard** grown as would be in normal conditions.
- **Negative** grown as farm standard but without any fertiliser applied.
- **Positive Aquagrain** grown as farm standard but without any fertiliser applied (but this to potentially be reviewed during the growing season)

As the Farm Standard were growing within the whole field no cane markings were used to mark out farm standard. Trial plot markings were as follows.

Negative were marked out using canes with **red tape**

Positive Aquagrain were marked out using **blue tape**.

In total 10 plots with distance of 10 metres between each one (figure 1)

	12 metres	Notes:
20 metres	Negative	No Fertiliser Applied
	10 m	
20 metres	Positive AG	No Fertiliser Applied
	10 m	
20 metres	Negative	No Fertiliser Applied
	10 m	
20 metres	Positive AG	No Fertiliser Applied
	10 m	
20 metres	Negative	No Fertiliser Applied
	10 m	
20 metres	Positive AG	No Fertiliser Applied
	10 m	
20 metres	Negative	No Fertiliser Applied
	10 m	
20 metres	Positive AG	No Fertiliser Applied
	10 m	
20 metres	Negative	No Fertiliser Applied
	10 m	
20 metres	Positive AG	No Fertiliser Applied
	12 metres	

Figure 1- Trial design

The trial plots were 12 metres in width and 20 metres in length. It was a rain fed trial, so no other means of irrigation used within the growing season.



Map 1- Trial site in Elveden, Thetford, UK

3.1 Aquagrain Application Rate

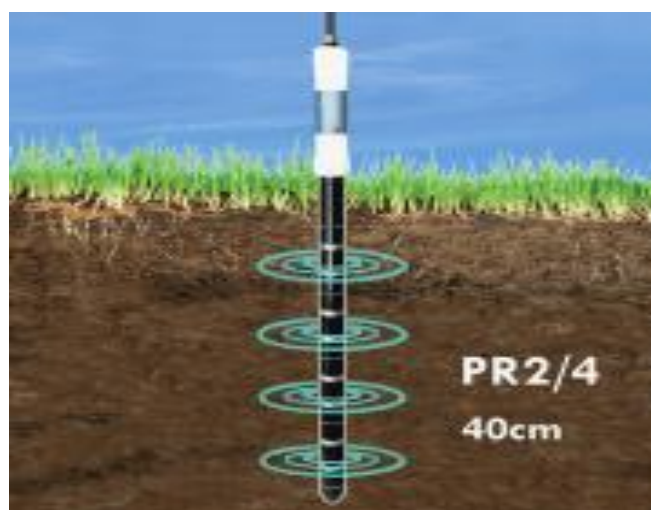
Aquagrain was applied manually using a hand pushed spreader at a rate of 500 kgs/ha which breaks down to **12kgs per trial plot**. The application took place before the field was cultivated. Harvesting took place on 20/07/2021 by a Sampo plot combine provided by EnviroField Ltd, Suffolk, UK (picture 1).



Picture 1- Sampo plot combine harvesting winter barley trial plots (20/07/2021)

3.2 Delta moisture probes

Three PR2 profile probes manufactured by Delta-T were installed in the treatments, one in each treatment. The PR2/4 model measures soil moisture at 4 depths down to 40 cm (picture 2) by emitting Electromagnetic Field. Soil moisture contents and water deficit were remotely reported by GP2 data loggers connected to each probe using the cellular modem options.



Picture 2- Delta-T PR2 profile probe. Courtesy of Delta-T

3.3 Field Activity Timelines

	Negative control	Farming standard	Aquagrain
Aquagrain application (26/10/2020)			
Drilling (28/10/2020)			
Post emerge Herbicides (06/11/2020)			
Chafer N30 + S 200,000 L/ha (25/02/2021)			
Chafer N30 + S 225,000 L/ha (23/03/2021)			
Manganese 15% 2000 L/ha (09/04/2021)			
Cebara (18569) 1000 L/ha (09/04/2021)			
Proline 275 (14790) 0.3 L/ha (09/04/2021)			
Chlormequat 750 (16690) (09/04/2021)			
Manganese 15% 2000 l/ha (20/04/2021)			
Hiatus (16059) 75000 g/ha (20/04/2021)			
Starane Hi-Load HL (16557) (20/04/2021)			
Yara Vita Magflo 300 (26/05/2021)			
Siltra Xpro (15082) (26/05/2021)			
Arizona (15318) (26/05/2021)			
Harvest (20/07/2021)			

Table 3- Trial activity from Aquagrain, fertilisers and -cides applications to harvesting

Month	Oct20	Nov20	Dec20	Jan21	Feb21	Mar21	Apr21	May21	Jun21	July21
Rain fall (mm)	82.5	37	79	87.5	36.5	43	2	71.5	61	16.5

Table 4- Rain fall during the trial

	Average crop moisture content (%)
Negative control	14.56
Farming standard	No data available
Aquagrain	13.46

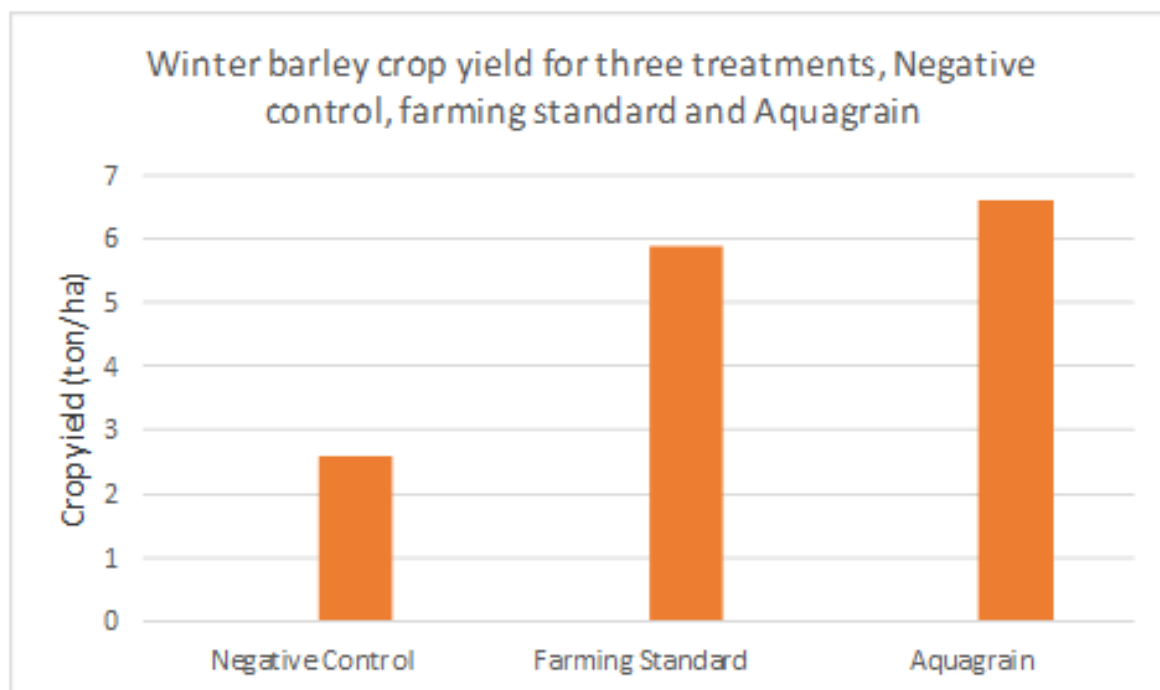
Table 5- Average crop moisture content for winter barley trial in Elveden

3.4 Results and Discussions

The winter barley trial was harvested on 20/07/2021 by a Sampo plot combine provided by EnviroField, Suffolk, UK (picture 1). The crop yields are shown in graph 1. Aquagrain treatment outperformed negative control by 2,6 fold (from 2.6 tons/ha to 6.6 tons/ha). Statistical analysis suggest that these differences are statistically significant ($p < 0.05$). Aquagrain also outperformed farming standard by 12% (from 5.9 tons/ha to 6.6 tons/ha). Aquagrain outperformed farming standard despite the fact that Aquagrain received less nutrient and 200,000 litres/ha less water (see table 3). On 25/01/2021 farming standard was the only treatment which was fertigated with Chafer N30 + S fertiliser and 200 L/ha of water.

Crop moisture content (table 5) also shows that Aquagrain treated crop contain less water (13.46%) than negative control (14.56%) suggesting that they should have higher density and probably higher sugar and protein content. These results are also statistically significant.

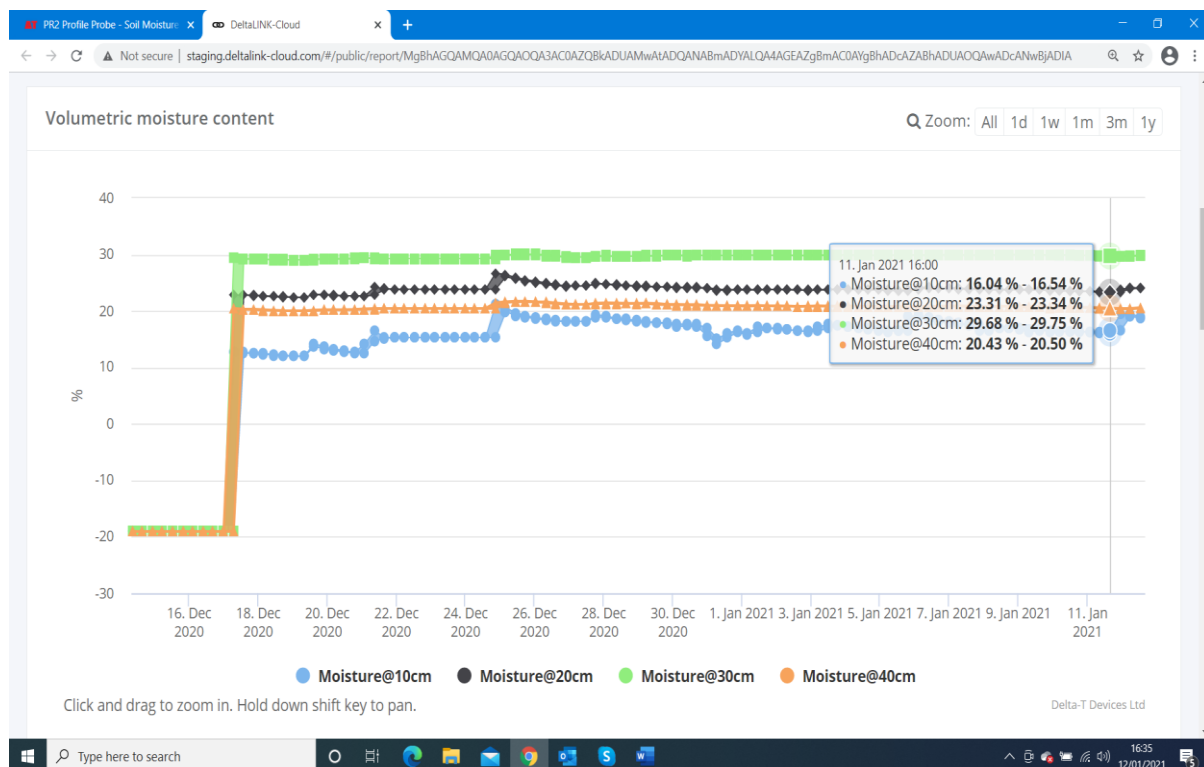
Aquagrain team did not really have high hopes of achieving good results from winter barley trial as initially when the trail was set up, rain fall was way above the expected average rain fall (table 4). However, dry season starting from February to July and particularly very dry April helped Aquagrain to demonstrate its effect.



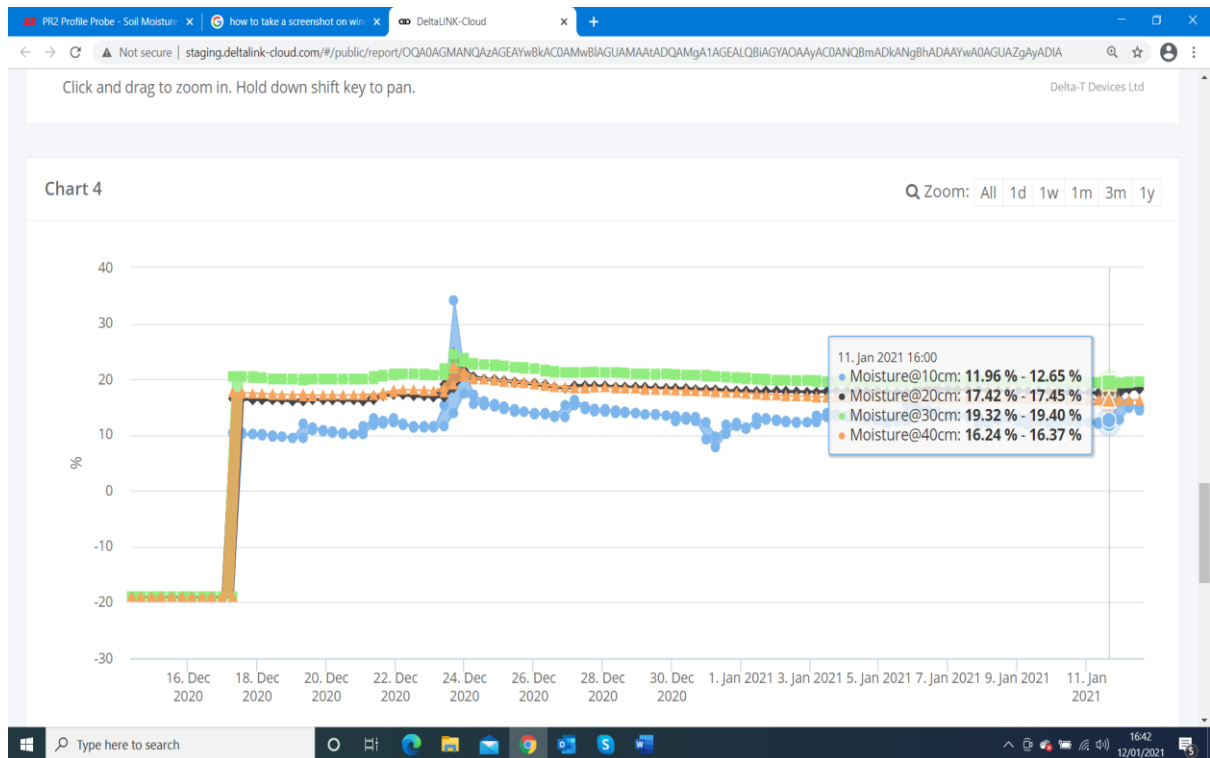
Graph 1- Crop yield for three treatments (tons/ha)

The moisture content reported by the moisture probes also suggested that there was more water in Aquagrain treatment. The date and the time chosen to demonstrate this effect is 11 January 2021 at 16.00 but no matter what day and time are chosen, the same conclusion

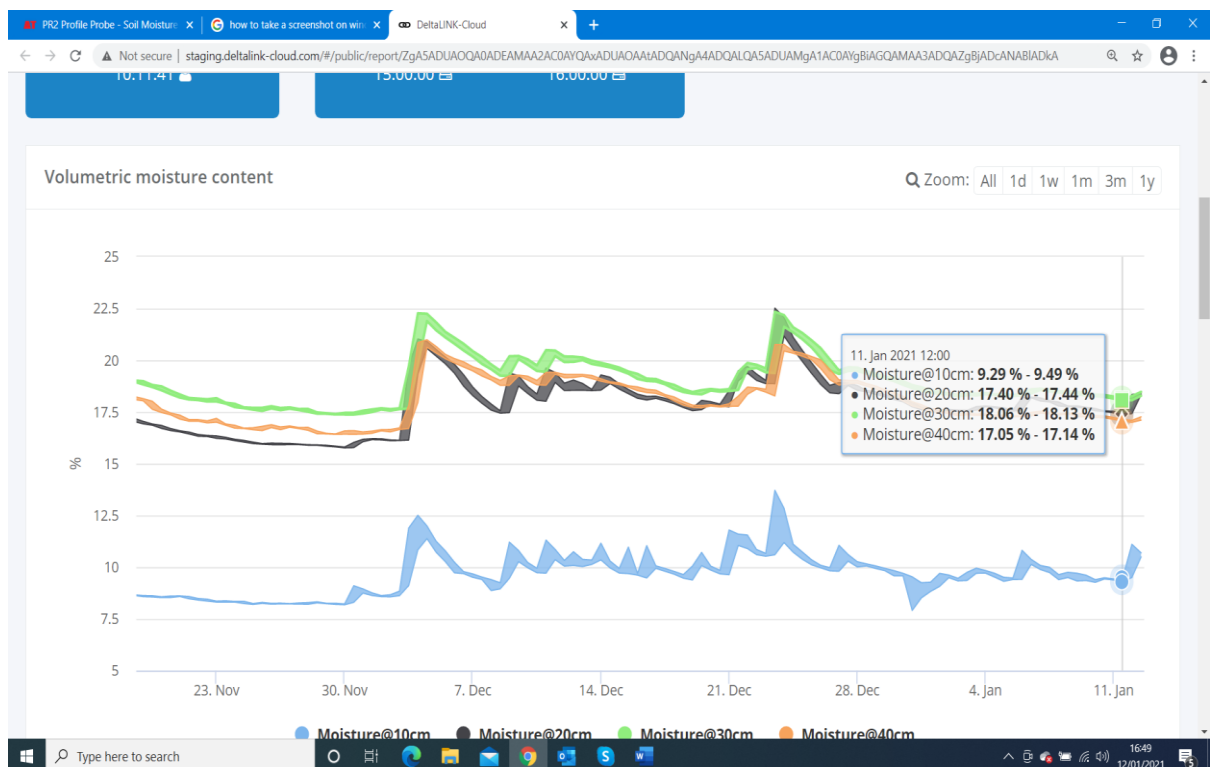
is drawn. In Aquagrain treatment at the depths of 10, 20, 30 and 40 cm, the moisture contents are approximately 16.5, 23.3, 29.7 and 20.5% respectively (picture 3) whilst at the same day and time point the farming standard treatment moisture content at the depths of 10, 20, 30 and 40 cm are approximately 12.2, 17.4, 19.4 and 16.3%, respectively (picture 4). As the probe installed in negative control (picture 5) was not synchronised with the other two probes, direct comparison was only possible between Aquagrain treatment and farming standard probes.



Picture 3- Soil moisture content (%) reported by PR2 probe in Aquagrain treatment



Picture 4- Soil moisture content (%) reported by PR2 probe in Farming standard treatment



Picture 5- Soil moisture content (%) reported by PR2 Probe in negative treatment

Water deficits which are the indication of how much water or irrigation needed to compensate the water loss, also suggest that Aquagrain treatment need significantly less water to get topped up. Water deficit at 16.00 on 11 January 2021 was roughly 10 mm (10 litre per square metre) for Aquagrain treatment (picture 6) however, at the same time point the water deficit for farming standard treatment (picture 7) was roughly 20 mm (20 litre per square metre). This is consistence at any chosen time point, however, after several dry days, this effect is more significant which is an indication of less water loss in Aquagrain treatment. This is expected as Aquagrain, as a water retaining polymer should indeed hold on to water and prevent its quick loss through leachate and evaporation. It should be however highlighted that these results are indicative only since each treatment has just one probe. To achieve more reliable results, more probes need to be used in each treatment making sure they agree with each other, and the results are consistent.



Picture 6- Water deficit for Aquagrain treatment



picture 7- Water deficit for farming standard treatment

Pictures taken from the treatments on 17/12/2020, after 50 days of trial commencement, also confirm that Aquagrain treatment is bushier and greener (picture 8) in comparison with farming standard (picture 9). At this point as no fertiliser is being applied then Negative control and farming standard are the same.



Picture 8- Aquagrass treatment plot (taken on 17/12/2020)



Picture 9- Farming standard treatment (taken on 17/12/2020)

3.5 conclusions

- Aquagrain outperformed negative control by 256% (from 2.6 tons/ha to 6.6 tons/ha) and farming standard by 12%
- Aquagrain received less nutrients and 200 L/ha water in comparison with farming standard but still outperformed it
- Moisture probes from Delta-T indicate that at each time point Aquagrain treatment holds 100,000 L/ha more water than farming standard treatment
- Crop moisture content also suggest that crops from Aquagrain has less moisture content in comparison with the negative control which suggest they probably have higher density, sugar and protein content since they have outperformed negative control

4. Spring Barley Trial Design

The same approach, experimental design, layout and plot sizes which were used for winter barley described in section 3 were also used to set up spring barley, although the location was different. The location of the trial was Brandon Field North.

The trial design had spring barley growing under 3 different treatments.

- **Farm Standard** grown as would be in normal conditions.
- **Negative** grown as farm standard but without any fertiliser applied.
- **Positive Aquagrain** grown as farm standard

4.1 Aquagrain Application Rate

Aquagrain was applied manually using a hand pushed spreader at a rate of 500 kgs/ha which breaks down to **12kgs per trial plot**. The application took place before the field was cultivated. Harvesting took place on 27/08/2021 by a Sampo plot combine provided by EnviroField Ltd, Suffolk, UK (picture 1).

4.2 Field Activity Timelines

	Negative control	Farming standard	Aquagrain
Aquagrain application (14/03/2021)			
Drilling (15/03/2021)			
Muriate of Potash (17/04/2021)			
Chafer N30 + S 300,000 L/ha (19/04/2021)			
Manganese 15% 2000 L/ha (10/06/2021)			
Bridgeway 1.954 L/ha (10/06/2021)			
Hiatus (16059) 50.195 g/ha (10/06/2021)			
Siltra Xpro 0.326 L/ha (10/06/2021)			
Bridgeway 1.954 L/ha (26/06/2021)			
Yara Vita Magflo 300 1.007 L/ha (26/06/2021)			
Siltra Xpro (15082) 0.415 L/ha (26/06/2021)			
Starane Hi-Load 0.385 L/ha (26/06/2021)			
Azural 4.000 L/ha (04/08/2021)			
Harvest (26/08/2021)			

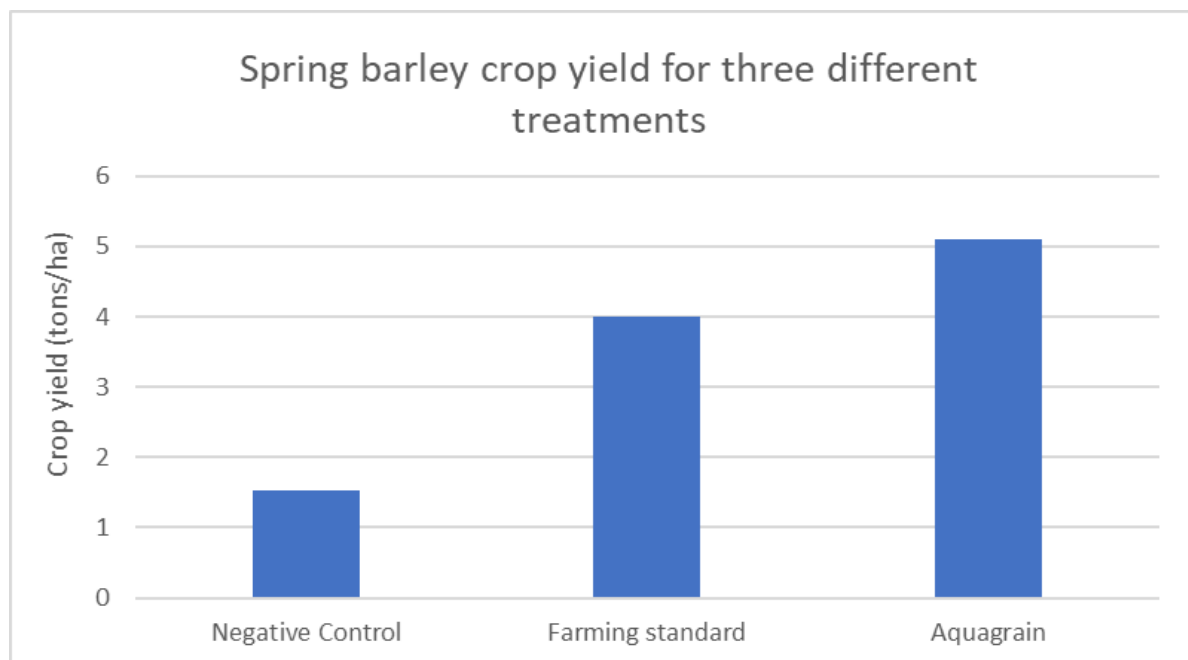
Month	March 21	April 21	May 21	June 21	July 21	August 21
Rain fall (mm)	40.4	0.5	79	57.5	46	25

Table 6- Rain fall during the trial

4.3 Results and discussions:

Graph 2 shows crop yields for three treatments, Negative control, farming standard and Aquagrain. The crop yield for these treatments are 1.52, 4.0 and 5.1 tons/ha respectively. Aquagrain outperformed negative control by 3.4 fold. Statistical analysis suggest this difference is significant ($p < 0.05$). Aquagrain also outperformed farming standard by 27.5%. Only average crop yield was provided with Aquagrain team so we were not able to statistically analyse the difference between farming standard and Aquagrain treatments. However, out of 20 samples taken from Aquagrain treatment, none had any overlap with Farming standard crop yield, suggesting that if statistical analysis were performed, it would have been very likely to see statistical difference.

Moisture content for Negative control and Aquagrain were 17.4 and 16.7% respectively but unlike winter barley these differences are not statistically significant.



Graph 2- Crop yield for three treatments (tons/ha)