BRIDGEWAY HANDBOOK

POWER CROPS, SECURE YIELD

2022

- Growth & development
- Nutrient-use-efficiency
- Stress protection
- Natural & renewable

INTERAGRO
THE ADJUVANT EXPERTS

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Welcome to our Bridgeway Handbook

Bridgeway is the leading amino acid and peptide biostimulant that promotes healthier, higher-yielding crops by stimulating growth, optimising resource-use-efficiency and increasing immunity against stressful growing conditions. Rich in all vegetal amino acids critical to growth, metabolism, nutrition and defence, Bridgeway is the natural renewable solution for growers looking to reduce dependence on synthetic inputs for more resilient and sustainable crop production.

At Interagro our class-leading biostimulants sourced only from plants, are produced with our unique extraction methods that ensure the highest purity and quality for your crops, backed by our rigorous trials and grower programmes.

With soaring fertiliser prices, climate change and the need for more renewable and sustainable inputs that promote regenerative farming practices, the plant health benefits of amino acids offers growers a chemical-free alternative to growth enhancement, nutrient-use-efficiency and stress mitigation. Bridgeway provides the optimum concentration of amino acids and stimulating peptide complex that crops need for more efficient and resilient growth, with a wealth of data behind it.

Stuart Sutherland, Technical Manager at Interagro

“For more resilient and sustainable crop production”

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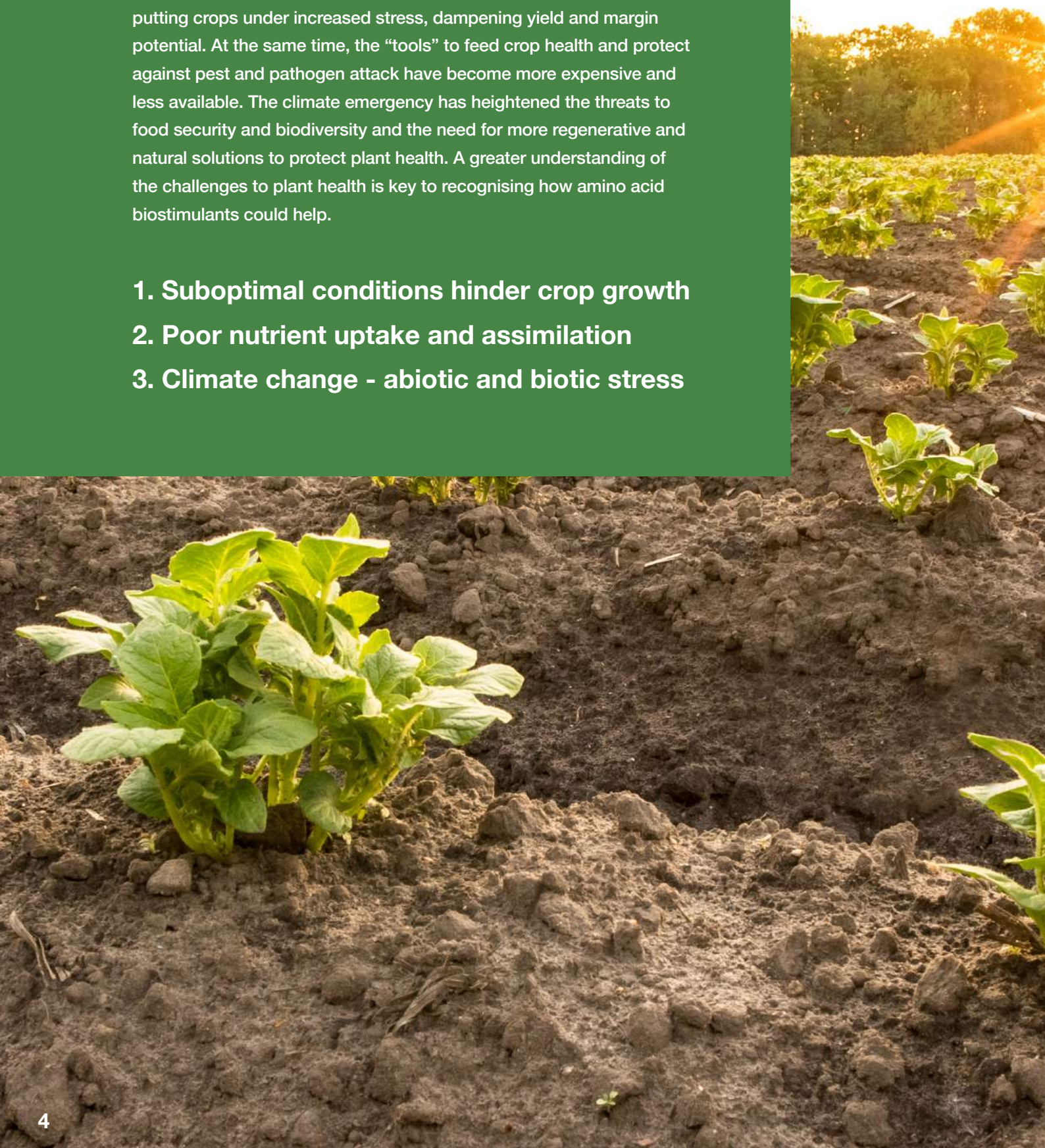
Plant health challenges

In recent years, the pressures on farmers to achieve high yielding, high quality crop production whilst making a profit, has intensified. The unpredictable weather has become more extreme, frequently putting crops under increased stress, dampening yield and margin potential. At the same time, the “tools” to feed crop health and protect against pest and pathogen attack have become more expensive and less available. The climate emergency has heightened the threats to food security and biodiversity and the need for more regenerative and natural solutions to protect plant health. A greater understanding of the challenges to plant health is key to recognising how amino acid biostimulants could help.

1. Suboptimal conditions hinder crop growth

2. Poor nutrient uptake and assimilation

3. Climate change - abiotic and biotic stress



1.
Suboptimal growing conditions hinder crop growth and development

Sunlight, temperature, water and nutrition are the 4 primary factors affecting crop growth and all impact the hormones that either stimulate or slow growth. If any one of them are out of balance, crop growth and development can be negatively affected, reducing yield and quality.

Sunlight

Directly influences the growth of plants by inducing photosynthesis and energy production. Light energy is captured by chlorophyll, and this energy is used to convert carbon dioxide and water into sugars and oxygen. The carbohydrates produced as a result of photosynthesis are used for vegetative and reproductive growth and to increase crop biomass. If sunlight becomes limited, plant growth will therefore slow.

Temperature

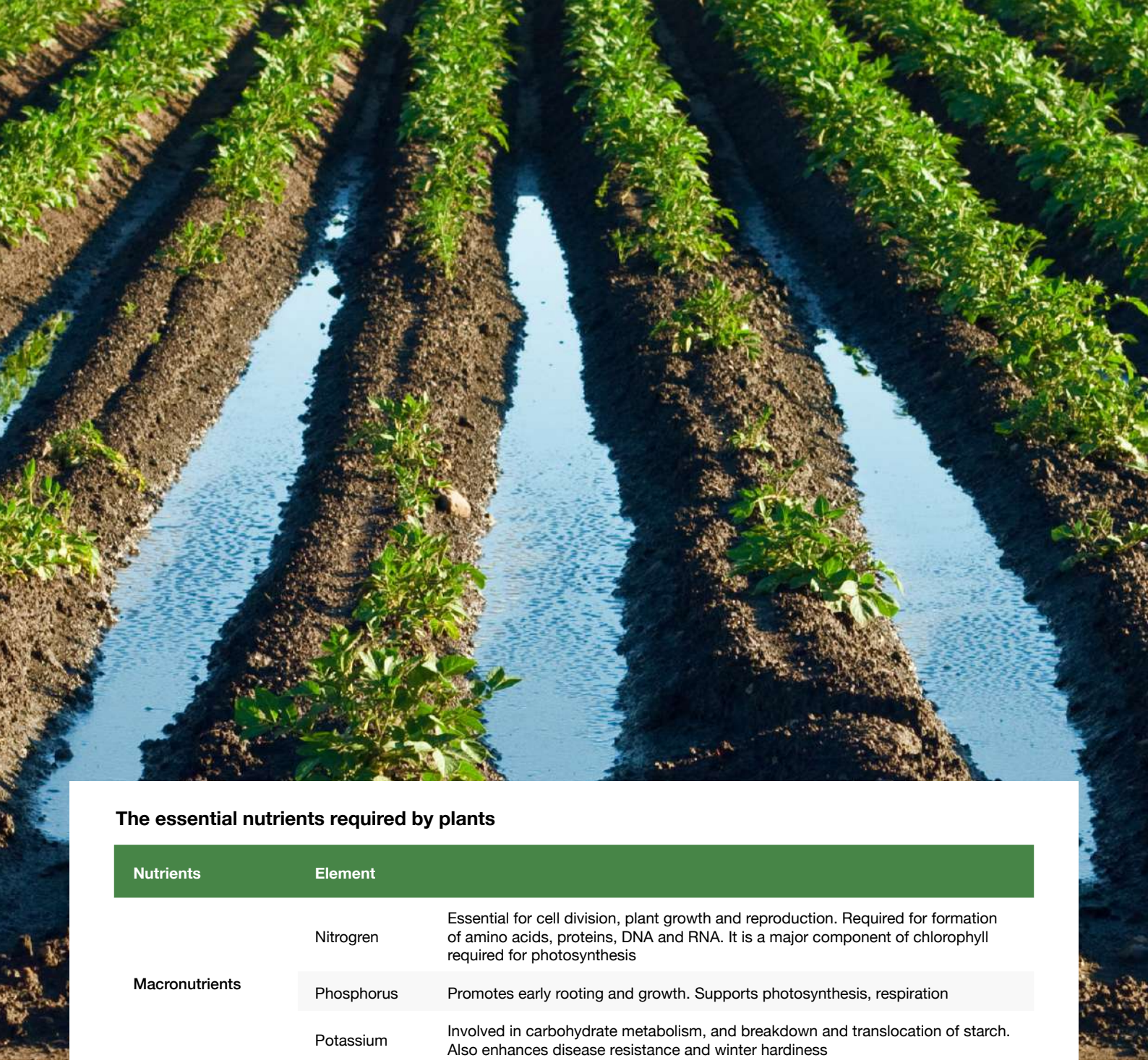
A primary environmental factor that affects plant development and growth rate. Air temperature, relative humidity and light all influence the ability of the plant to reach its optimal temperature and must be in balance for optimal growth. Plants cool off by increasing evaporation through transpiration and heat up by irradiance. Temperature influences most plant processes, including photosynthesis, transpiration, respiration, germination, and flowering. When temperatures are very low (how low depends on the plant variety), hardly any photosynthesis will occur. As temperature increases (up to a point), photosynthesis, transpiration, and respiration increase. Most biological processes within the plant will speed up at higher temperatures, but as temperatures reach the upper limit for the crop, the rate of energy used by respiration to keep cool, can exceed the rate at which energy is produced by photosynthesis. This results in less energy being available for fruit/grain development and leads to smaller yields. The process of transpiration and cooling is regulated by specialist organs in the leaves of plant cells called stomata, which open and close to limit the amount of water than can evaporate. The higher the temperature rises, the more water the stomata will evaporate when they are open, and the higher the exchange of gases (stomatal conductance) into and out of the plant, critical for photosynthesis. The rate of stomatal conductance is influenced by environmental factors, amino acids and the plant hormone abscisic acid, which regulates ion concentration in the stomata.

Water

An essential ingredient for photosynthesis, to moderate the temperature of the plant through transpiration, and key for the translocation of nutrition through the plant. As water evaporates through transpiration, more water is pumped from the soil, through the roots into the plant, carrying the essential nutrients required for plant growth. Too little water can cause plants to wilt, whilst too much can cause roots to rot. Plants exposed to water stress have their cells damaged by fee radicals.

Nutrition

Crucial for the healthy growth, development and production of plants, but often limited by availability. Plants require 13 essential nutrients, with nitrogen and phosphorus being critical. In many cases nitrogen is the limiting essential element. Nitrogen shortage causes detrimental effects on agricultural productivity, yet excessive nitrogen fertilisation accounts for negative economic and environmental impacts. Improving nitrogen-use-efficiency represents a main challenge for agriculture.



The essential nutrients required by plants

Nutrients	Element	
Macronutrients	Nitrogren	Essential for cell division, plant growth and reproduction. Required for formation of amino acids, proteins, DNA and RNA. It is a major component of chlorophyll required for photosynthesis
	Phosphorus	Promotes early rooting and growth. Supports photosynthesis, respiration
	Potassium	Involved in carbohydrate metabolism, and breakdown and translocation of starch. Also enhances disease resistance and winter hardiness
Secondary nutrients	Calcium	Increases fruit set and quality
	Magnesium	Core component of chlorophyll. Improves mobility and utilisation of phosphorus
	Sulphur	Integral part of amino acids. Supports enzyme and vitamin synthesis and involved in formation of seeds
Micronutrients	Boron	Essential for cell wall formation, for germination of pollen grains and growth of pollen tubes
	Zinc	Supports plant growth hormones and enzymes. Required for chlorophyll and carbohydrate production
	Copper	Required for photosynthesis. Improves flavour of fruit and vegetables and natural defence from ergot
	Manganese	Supports chlorophyll synthesis and increases availability of magnesium and phosphorus
	Iron	Promotes formation of chlorophyll and transports oxygen in the plant
	Chloride	Promotes plant health
	Molybdenum	Required to convert inorganic phosphorus to organic phosphorus in the plant and supports legume nodulation especially in acidic soils

2.
Poor nutrient uptake and assimilation reduce nutrient-use-efficiency

Improving crop nutrient efficiency is an essential consideration for profitable and sustainable crop production. In a typical season, the average nitrogen-use-efficiency of crops is reported to be at around 60%, meaning 40% is not being used. Reduced access to nitrogen or phosphorus severely constrains crop growth and productivity levels in soils, and therefore there are clear priorities for improving nutrient efficiency in crops. Research has shown that nearer 80% is achievable and what growers should be aiming for. So why is efficiency so low and how can it be improved?

Nitrate leaching reduces crop access

Not all nitrogen in soil can be taken up by crops, even if they need it. Unused nitrogen can be leached beneath the root zone of the crop by heavy rainfall. This can be harmful to watercourses and reduces nutrient efficiency. Nitrate is highly soluble and mobile so will always move. Fertiliser applications should therefore always be tailored to the needs of the crop to minimise leaching and maximise efficiency. The following 5 point plan will help:

- Maintain green cover for as long as possible to absorb excess nitrogen
- Assess crop need – sample soils for soil mineral nitrogen and leaf tissue test
- Ensure balanced P, K and S to optimise nitrogen uptake - amino acid biostimulants can help
- Develop a deep and expansive root system to capture available nutrients - amino acid biostimulants can help
- Split applications to meet crop needs in-season

Lazy roots limit uptake

Root exploration is the main determinant in the ability of plants to acquire nutrients and water from the soil. However, too much water during the growth phase can severely reduce deep rooting. With plenty of water in the upper profile of the soil, plants become lazy as there is no need to put down deep roots, accessing water and nutrition through surface roots. The consequence is that when soils dry out in the upper layer, water and nutrients become limiting, crops lack the root length density to access water and nutrition lower down in the soil, impacting healthy growth and yield potential. Root architecture is therefore of major importance in increasing crop nutrient-use-efficiency. There's not much that can be done to prevent heavy rain, but biostimulants can be used to stimulate rooting and help build stronger root systems.

Organic fertilisers are not readily accessible to crops

Organic fertilsers, such as manure, are good natural sources of valuable nutrients, but they have the disadvantage of not supplying crops with nutrients in an easily absorbable, water-soluble form when crops need them as organic nitrogen needs to be mineralised before it can absorbed. Growing crops with more robust root systems and higher nutrient-uptake efficiency to ensure plants can take up the nutrients when they become available, is key to make the most of organic fertilisers.

Deficiency stress leads to poor efficiency

Deficiency stress is triggered by a nutritional imbalance that effects a plant's physiological activity. This stress limits the potential for the plant to grow and thrive in its environment. A stressed plant, regardless of the type of stress, does not assimilate or transport nutrients as efficiently as a plant not subjected to stress. In addition, the nutritional deficiency makes the plant much more sensitive and vulnerable to other types of stress: cold, frost, salinity, drought, pathogen attacks, etc

Why amino acids?

- Essential unit for protein formation critical to plant health.
- Required by plants in high concentrations to support physiological and biochemical processes.
- Large concentrations required by chloroplasts for photosynthesis and mitochondria for respiration.
- Accelerate growth and enhance plant productivity, especially under abiotic and biotic stress conditions.
- Build robust root systems to optimise capture of water and nutrients from the soil.
- Increase nutrient-use-efficiency and potential to reduce dependence on synthetic fertiliser.
- Bio-activators providing the energy to compensate for losses caused by respiration and decomposition processes.
- Increase the anti-oxidant content of leaves, detoxifying free radicals that cause damage to cells.
- Change the osmotic potential of plant tissue and greatly reduce injuries caused by bio-stresses.
- Enable photosynthesis, and therefore energy production and growth to continue in stressful growing conditions.
- Stimulate the natural defence systems of plants, building tolerance and resilience to suboptimal growing conditions.
- Increase the chelation of metal ions making them more absorbable through leaf tissue.

Could amino acids be one of the most overlooked assets in plant nutrition?

In addition to the core nutrients needed for growth, plants also depend on amino acids - the building blocks of all living cells, which plants combine together in infinite variations to produce countless different proteins critical for healthy growth and development. These amino acids and proteins play a vital role in virtually every process within plants.

All plants can synthesise the 18 L-amino acids they need by combining glucose, produced from photosynthesis, with inorganic nitrogen sourced from nitrate in the soil. The process includes the transformation of nitrate into nitrite and ammonium, and eventually into an organic molecule resulting in the amino acid glutamic acid. With glutamic acid as a base, the plant can synthesise all other amino acids through transamination processes.

Incapable of creating reserves, as proteins have a finite lifespan, a continuous supply of amino acids must be translated for plant growth and development to continue. However, amino acid and protein synthesis uses significant expenditures of energy and when plants are under stress or when the raw materials to produce amino acids become limited, they are unable to perform their normal physiological functions to make these amino acids.

As photosynthesis and nitrate / ammonium fertilisers are the typical sources for amino acid and protein production, any deficiencies or environmental conditions that reduce photosynthesis or limit N access, can have huge implications on plant growth and development. The consequence is that when plants are under stress or nutrient deficient, amino acid production stops and plants break down the proteins they have already made to gain access to the specific amino acids they need. Plants subjected to stress show accumulation of proline and other amino acids.

Supplementing crops with amino acids offers potential to increase nitrogen-use-efficiency and enhance the quality and health of plants.

3.
Climate change is increasing the prevalence of abiotic and biotic stress to plants

Abiotic stress is a major constraint on crop production and food security worldwide and is defined as environmental conditions that reduce growth and yield below optimum levels. With the effects of climate change increasing, abiotic stress factors such as heat, cold, drought, salinity, and nutrient stress are becoming more prevalent, reducing average yields by >50% in some parts of the world. In addition to this, plants must defend themselves from attack by a vast range of biotic stresses in the form of pests, pathogens and weeds. Each stress elicits a complex cellular and molecular response system implemented by the plant in order to prevent damage and ensure survival, but often at the detriment of growth and yield.

Drought stress

Drought stress is one of the most prevalent and damaging stresses to plants. Many physiological, morphological, biochemical and molecular processes in plants are impaired by drought stress, including photosynthesis, enzyme activity, cell membrane stability and pollen viability. The water deficit affects numerous aspects of plant growth, with the most apparent effects of water stress being expressed by the reduction of plant size, leaf area, and crop productivity.

Heat stress

Heat stress is a prime constraint on productivity as it interrupts some of the most important physiological and biochemical process of the plant. High temperature stress stops photosynthesis and reduces chlorophyll and starch formation in the endosperm. Exposure of wheat to short episodes (2-5 days) of heat stress (above 24°C) at the start of ear formation can damage fertility, whilst temperatures >35°C can cause total failure. Over a prolonged period this can lead to significant grain losses whilst heat stress later in the season can reduce the length of the grain fill process. For root crops such as potatoes, heat stress can be extremely damaging. Fluctuations in temperature between hot and cold, lead to erratic growth that cause issue with tuber size, numbers and impacts quality, often resulting in growth cracks and russeting. The earlier in the season heat stress occurs, the more negative its impact on the growth and yield of the crop. Temperatures above 25°C delay tuberisation by inhibiting carbon synthesis and translocation to the stolon. Every 5°C increase above the optimum temperature of 20°C can decrease the rate of photosynthesis by 25%. Temperatures above 30°C, can cause complete inhibition of photosynthesis and significantly impact the partitioning of sucrose translocation to tubers.

Frost stress

Frosts can cause severe damage to some crops such as early and main crop potatoes. Recovery of the crop depends partly on the variety and also on the growth stage. Whilst affected crops can normally re-sprout, growth will be set back weeks and will likely impact final yield and harvest date.

Biotic stress

Biotic stress agents directly reduce the nutrient availability of the host plant, reducing crop vigor and causing death of the plant in extreme cases. Plants respond to biotic stress through a defence system that creates oxidative bursts to stop pathogen spread and by lignifying cell walls to block invasion. The defences to biotic stress include morphological and structural barriers, chemical compounds, and proteins and enzymes. These confer tolerance or resistance to biotic stresses by protecting cells and by giving them strength and rigidity. The plant hormones ethylene, salicylic acid and jasmonic acid play a key role in signalling stress responses, all influenced by amino acids.

Crop growth under less than optimum conditions due to environmental, chemical and disease stresses can severely impact the health and yield of plants. Therefore, there is a need to aid the plant in overcoming stress to maintain more uniform, healthier and stronger crops throughout the growing season. Directly and indirectly affecting plant growth, amino acids have a key role to play.

Naturally rich building blocks for your plants

Bridgeway is the leading amino acid biostimulant that contains the richest, purest source of all L-amino acids required by plants for healthy growth and development. Sourced exclusively from plants, Bridgeway is the perfect nature-based solution for growers looking to incorporate the benefits of amino acids into their agronomy programmes because it contains all 18 essential L-amino acids that have a physiological, biochemical and morphological effect on plant health:

- Every L-amino acid in an immediately available and usable form that can be readily absorbed, transported, and utilised, saving the energy usually expended by plants to reduce organic matter, synthetic nitrates and ammonia into amino acids
- Provides the ready-made building blocks for protein synthesis critical for plant structure, metabolism, hormones, nutrient transport and amino acid stock
- Novel approach for regulation and modification of physiological processes in the plant to stimulate growth, mitigate stress-induced limitations, and increase yield
- Provides glutamic acid, central to plant metabolism, in high concentrations

Contents

Composition	%
Vegetable amino acids and peptides	31.25%
Organic nitrogen	5%
Biological organic carbon	17.8%
Carbohydrates	9%

Bridgeway L-amino acids and function in plants

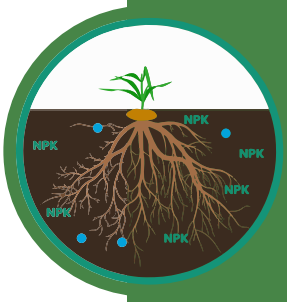
L-Amino Acids	Function in plants
Glutamic Acid	The precursor to all other amino acids; stimulates plant development; aids absorption of inorganic nitrogen; increases resistance against weather related stress
Aspartic Acid	An important metabolic hub for the biosynthesis of many metabolites, amino acids, proteins and hormonal conjugates that play a crucial role in growth and development, and response to environmental conditions
Lysine	A precursor for glutamate, an important signalling molecule amino acid that regulates plant growth and responses to the environment
Arginine	Due to the highest nitrogen to carbon ratio among the 21 proteinogenic amino acids, arginine is a major storage and transport form for organic nitrogen in plants in addition to its role as an amino acid for protein synthesis, a precursor for essential metabolites for many cellular and developmental processes. In seed proteins of different plant species 40–50% of the total nitrogen reserve is represented by arginine
Serine	Plays a fundamental role in plant metabolism, development and cell signalling including rooting
Valine	Branched forms serve as alternative energy source. Involved in seed development and amino acid homeostasis
Tryptophan	Fundamental precursor of auxin which regulates plant growth and development. Core to cell division, elongation and differentiation, embryonic development, root and stem tropisms, apical dominance, and transition to flowering
Methionine	Precursor to ethylene which stimulates ripening
Proline	Protects plants from stress and helps plants to recover more rapidly
Histidine	Plays a critical role in plant growth and development. Supports metal ion homeostasis
Isoleucine	Branched forms serve as alternative energy source
Leucine	Important role in plant defence systems. Leucine-rich repeat receptors detect pathogens as part of immune response
Phenylalanine	Serves as a building block for many compounds essential to plant structure, reproduction, defence and communication
Threonine	Significant role in chemical defence against abiotic stresses. Also involved in plant growth and development, cell division, and regulates the phytohormones
Tyrosine	Precursor of many specialised metabolites that have diverse physiological roles e.g. electron carriers, anti-oxidants and defence compounds
Alanine	Important role in plant physiology and metabolism, and directly as a defence compound by enabling plants to withstand stress, such as waterlogging and drought
Cysteine	Central role in fixing sulphur from the environment and a precursor for many bio-molecules e.g. plant defence compounds
Glycine	Increases nitrogen status and concentration of nutrients in plant tissues, helping to mitigate fertiliser requirements in crops

The biostimulant to nourish and protect

Bridgeway provides triple action power to crops through biostimulation, nutrition, and anti-stress action to nourish and protect your crops under increasingly adverse growing conditions. Chemical free and produced using our cutting-edge enzymatic hydrolysis techniques to preserve all the bioactivity and natural goodness, you can be confident in knowing Bridgeway amino acids are the best source for healthy higher yielding crop production.

- **Optimises plant growth and development**
- **Increases nutrient-use-efficiency**
- **Protects against abiotic and biotic stress**
- **100% natural and renewable**

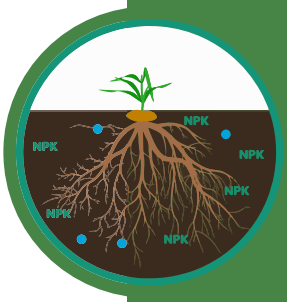
Powers crops, secures yield



Optimises plant growth and development

Stimulates growth and strengthens all plant parts

Bridgeway contains high levels of root stimulating amino acids and peptides that increase the lateral roots and root length density of plants. The more robust and expansive root systems enable crops to capture nutrients readily available in the soil and leached water and nutrients lower down. Building strong root systems with Bridgeway early in the life of the crop ensures the supply of water for photosynthesis and transpiration that is needed for highly efficient crop production. The stimulation of growth regulating phytohormones also promotes shoot growth and biomass production, supported by more abundant resources to optimise plant growth and development.



Increases nutrient-use-efficiency

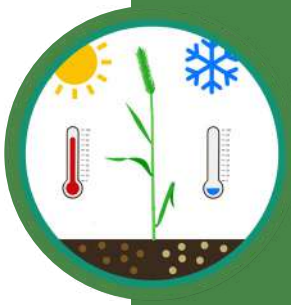
Maximises nutrient uptake, transport and use

Bridgeway increases nutrient uptake and the translocation of both macro- and micro-nutrients within the plant, by changing root morphology, improving micronutrient mobility in the plant, and by increasing activity of NO3-assimilation enzymes. The small molecular weight of L-glycine and L-glutamic acid, natural chelating agents, also support the assimilation of metals such as Fe, Zn, Mn and Cu, by making them more readily absorbable through roots and leaves. The efficient provision of all L-amino acids in an immediately available and useable form, could help reduce the dependence on nitrate and ammonium fertiliser as an N source for amino acid and protein synthesis. Supplementing crops with Bridgeway offers huge potential to increase nutrient-use-efficiency and enhance the quality and health of plants.

Supplies more energy to the crop

Speeds up photosynthesis

Bridgeway increases chlorophyl production in plants, increasing the rate of photosynthesis. The higher glucose production provides more energy for crop growth which is particularly advantageous at key development growth stages when energy demand is high. The ability of Bridgeway to help stabilise photosynthesis during the season is key to protecting the yield and quality potential of the crop when abiotic and biotic stress would usually reduce the plant's energy supply, suppressing growth.



Protects against abiotic and biotic stress

Supports the defence systems of plants

Bridgeway provides an immediate supply of stress-acting amino acids that signal the defence systems of plants, avoiding the recycling of proteins to amino acids at huge cost to the plant. Under low temperature, water deficit, salinity stress, and high UV exposure, stress-busting proline accumulates in cells where it is needed to suppress oxidative stress, and secure osmotic balance to maintain cell turgor when water is limited. Under heat stress, Glutamic Acid (in high concentration in Bridgeway) acts as an osmotic agent triggering stoma to open, enabling photosynthesis, water and nutrient absorption to continue, even during stressful growing conditions. Bridgeway helps plants to adapt to stressful growing conditions and rapidly resets the balance between stress resistance and growth, critical to secure yield and quality potential.

Key situations to use Bridgeway

- Help build robust root systems in winter and spring crops to increase ability for water and nutrient scavenging at depth
- Pre-T0 + T0 in moderate and high input wheat varieties to build the plant's natural defences against invading diseases
- Prior to fertiliser applications to minimise leaf scorch and optimise nutrient uptake and assimilation in the plant
- Early sugar beet establishment to maintain photosynthesis and increase tap root bulking - 3 applications optimal
- To optimise the chelation of metal ions within the plant
- At T1 and T2 in barley to minimise stress which is a trigger for ramularia

- In the tank with ethephon-based PGRs in wheat and barley to minimise stress to the crop and reduce lodging and brackling to protect yield and quality
- Support recovery from abiotic, biotic and chemical stress. Apply ahead of anticipated stress for best results
- Alleviate transplanting and establishment stress for veg and fruit crops
- In potato crops to maintain photosynthesis during heat stress (>25°C) so tuber bulking can be maintained for yield – 2 to 3 applications optimal
- At the key stages of development In organic systems – all crops - to optimise plant health and protect against abiotic and biotic stress

Performance in trials

Improved growth and development

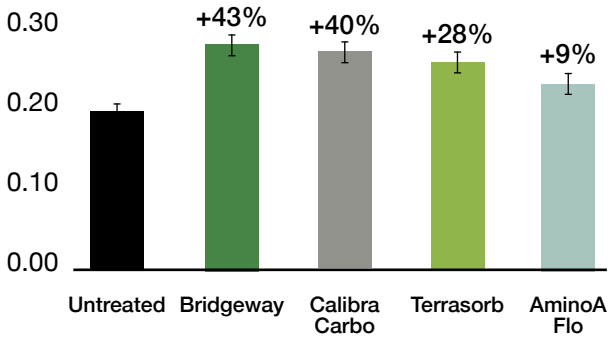
Rooting

+43% roots, + 31% shoots

The rooting ability of crops has huge consequences on plant health. Plants with bigger roots can not only extract more water at depth, they also have a greater ability to sequester more carbon - key to helping the NFU achieve it's target of Net Zero by 2040. Research at the University of Nottingham over the last few years in wheat, barley and oilseed rape, has shown Bridgeway significantly increases root and shoot growth, and is one of the best biostumulants on the market.

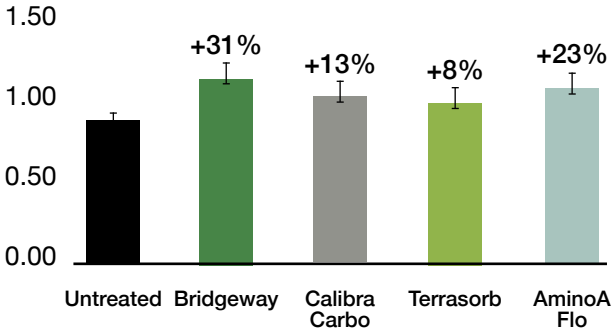
Bridgeway - biggest effect on roots

Effect of biostimulant on root growth in winter wheat
Mean root dry weight (g) at 95% CI



Bridgeway - biggest effect on shoots

Effect of biostimulant on shoot growth in winter wheat
Mean shoot dry weight (g) at 95% CI



University of Nottingham 2019. Winter wheat cv Siskin. Trial terminated 30 days after treatment application. 10 replicates per treatment. Treatments applied at GS 14. Bridgeway applied at 1 L/ha; Terrasorb 2 L/ha; AminoA Flo 2 L/ha.

Increased root and shoot growth in Maize, 2020

Photo courtesy of agronomist

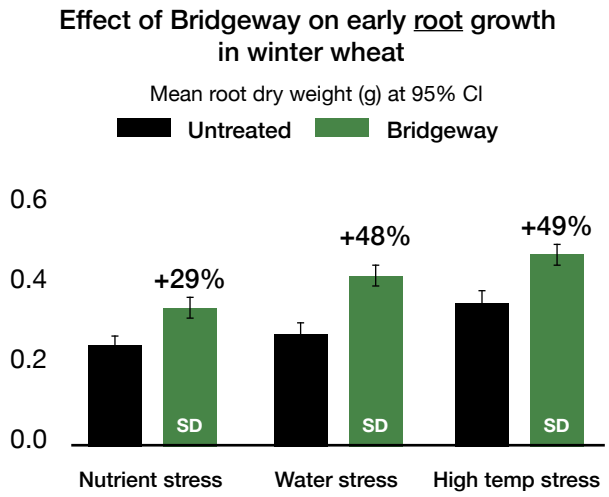
Bridgeway **Untreated**

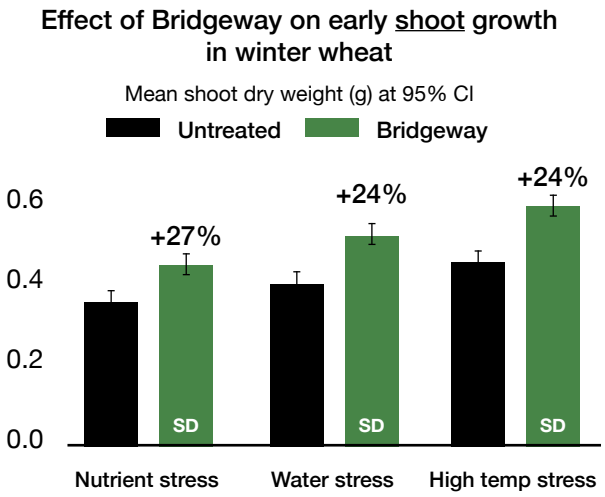
Bridgeway **Untreated**

Bridgeway 1.3 L/ha applied at 5 leaf stage

Significant increases in root and shoot growth under stress

Further research at the University of Nottingham looked at the effect of Bridgeway on early root and shoot growth in stress-induced winter wheat (Siskin). Plants were treated with Bridgeway at 2.0 L/ha, at GS14 and the effects on root and shoot growth were determined 24 days after application. Low nutrient stress was achieved by feeding with a 10% rate of the standard feed; water stress, by irrigation every fourth day rather than daily or when the plants started to show drought symptoms; and heat stress, where plants were under standard feed and irrigation at a constant 30^{0}C. Bridgeway increased root and shoot growth significantly in all scenarios tested.





Source: University of Nottingham 2018. Winter wheat cv. Siskin. Treatments applied at GS14. SD = significant difference compared to untreated.

High temperatures stress untreated control

High temperatures stress Bridgeway

Key takeaways

- Bridgeway gave very positive and statistically significant effects on plant growth, with larger effects consistently observed with root growth.
- Similar effects were seen with shoot growth, but the effects weren't so big suggesting the driving parameter is enhanced rooting.
- There was an indication that the enhanced root growth was greater when the plants were stressed, especially for water and high-temperature stress, yet the improvements were still very beneficial and statistically significant in non-stressed wheat.
- Best returns will be from using Bridgeway in a programmed approach, integrated with existing agronomic practices.

Increased nutrient-use-efficiency

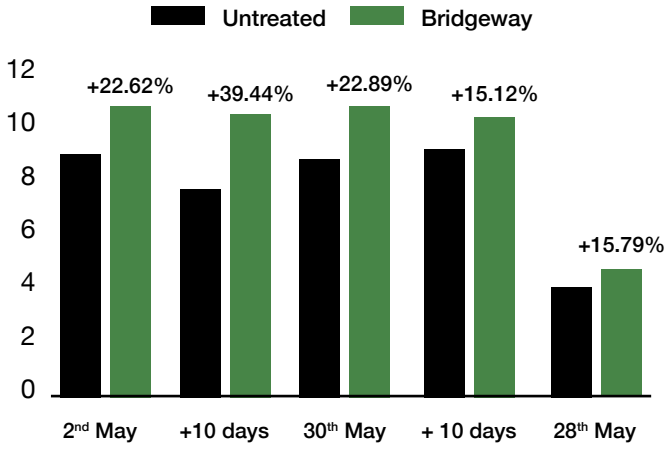
Nutrient uptake

Higher photosynthesis & nutrients

In 2018, Bridgeway was applied to a crop of Skyfall on a high calcium Cotswald brash soil, 2.5 L/ha at both T1 and T2, and 2 L/ha at T3. Regular leaf tissue samples were taken before applying Bridgeway and after applying, along with Brix assessments for a measurement of the sugar content in the sap. The treated crop had a noticeable uptake in nutrients compared to the untreated. The amino acids can help the crop use the water and nutrients that's available more efficiently, this was the big benefit where moisture was very limited that season.

Bridgeway treated crops had higher sugars

Effect of Bridgeway on Brix in winter wheat

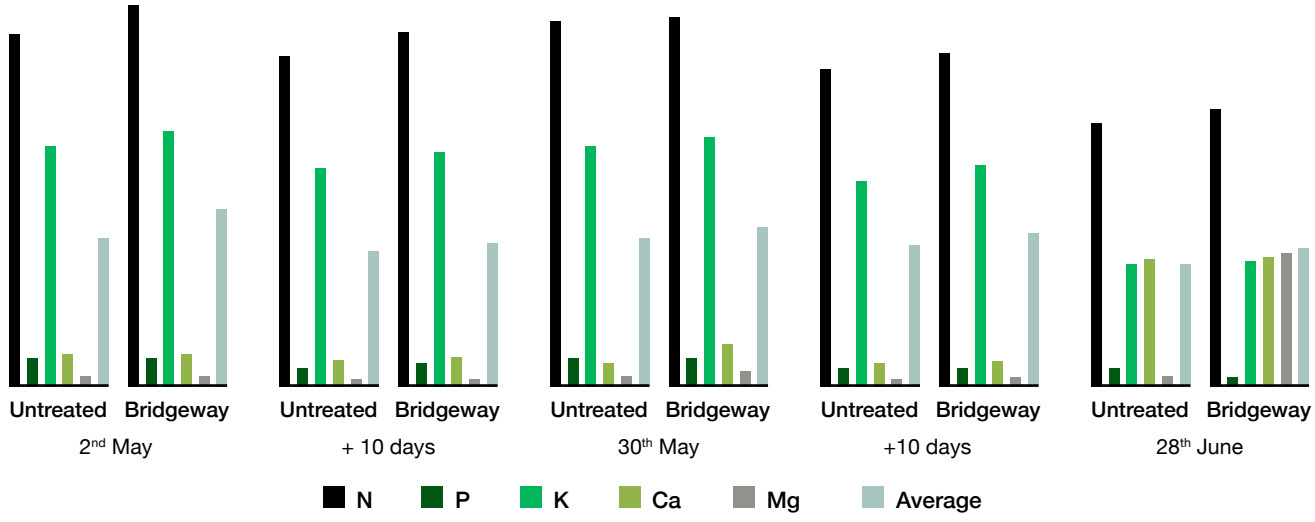


Key takeaways

- Bridgeway treated crops had higher Brix readings (+16-39%) throughout the season, compared to untreated crops. Brix is a measure of sugars in the plant and shows Bridgeway increased the rate of photosynthesis.
- Bridgeway increased nutrient uptake at each assessment.
- Bridgeway increased all grain nutrients except copper - a valuable benefit for home-saving seed.
- Bridgeway treated Skyfall ended up achieving 12.8% protein with a mean yield of 12.9 t/ha compared to the untreated areas of 11.3% protein and a mean yield of 11.0 t/ha. This was a good result in Skyfall, where proteins can cause an issue.
- The extra proteins were still achieved with Bridgeway without applying a late N protein spray, which wasn't applied due to the very hot conditions.

Bridgeway treated crops had higher nutrient uptake compared to untreated crops

Effect of Bridgeway on nutrient uptake in winter wheat



Source: Tramline trial data courtesy of Kieran Walsh 2018.

Improvements in nutrient uptake in winter wheat

Nutrient	Units	Untreated	Bridgeway	Difference
N	%	4.4	4.73	**+7.5%**
P	%	0.34	0.4	**+17%**
K	%	2.43	2.65	**+9%**
Ca	%	0.37	0.42	**+14%**
Su	%	0.3	0.36	**+20%**
Mg	%	0.12	0.13	**+8%**
Mn	ppm	83.7	99	**+18%**
Bo	ppm	3.9	3.7	**-5%**
Cu	ppm	13.6	17.3	**+27%**
Mo	ppm	1.43	1.62	**+13%**
Fe	ppm	99	105	**+6%**
Zn	ppm	27.8	29.7	**+7%**

Bridgeway increased uptake of all nutrients except Boron. Potassium moved from slightly low to low. Calcium move from slightly low to normal.

Cheltenham 2018. Leaf sampling 15th May 2018. Assessment by Yara.

Important gains in nutrient uptake for P, K & Boron in winter beans

Nutrient	Units	Untreated	Bridgeway	Difference
N	%	6.27	6.24	**-0.5%**
P	%	0.53	0.58	**+9.43%**
K	%	2.63	2.84	**+8%**
Ca	%	0.39	0.39	**0%**
Su	%	0.24	0.25	**+4%**
Mg	%	0.21	0.21	**0%**
Mn	ppm	26.7	36.1	**+35%**
Bo	ppm	19.9	24	**+21%**
Cu	ppm	18	21.3	**+18%**
Mo	ppm	0.59	0.81	**+37%**
Fe	ppm	103	170	**+65%**
Zn	ppm	48.5	46.6	**-4%**

Bridgeway increased uptake of most nutrients except Nitrogen, Sulphur & Zinc. Boron moved from very low to low.

Markle Mains East Lothian 2018. Leaf sampling 13th June in Beans. Assessment by Yara

SCOTTISH AGRONOMY LTD

Improved protection against abiotic and biotic stress in Cereals

Anti-stress

Ramularia disease control in spring barley

Bridgeway is part of ongoing trials work at Scottish Agronomy investigating the use of non-fungicidal options for the control of Ramularia in spring barley. Ramularia is potentially the most yield limiting disease affecting barley in Scotland. If uncontrolled, the disease can reduce yields by over 20%, and significantly affect grain quality. Previously the disease has been well controlled by fungicides. Since 2017 however, the disease has developed resistance to systemic fungicides, rendering them almost completely ineffective. The only remaining non-systemic crop protection is Folpet (Arizona).

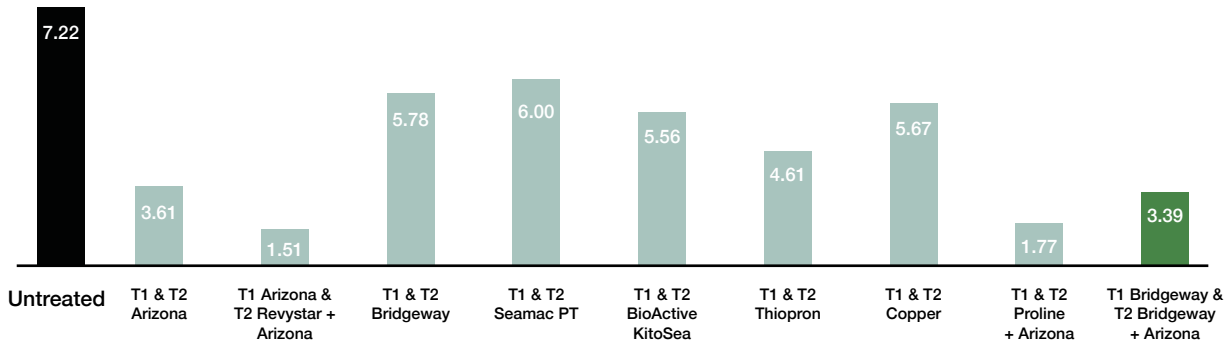
In 2021 (year 2 of work), Bridgeway was included as one bio- option to help to delay or alleviate the severity of the disease. Bio-elicitors and other biological products can help to stimulate the host plants natural defence mechanism. Replicated trials in spring barley were established in three areas – Borders (South), Fife (Central) and Aberdeenshire (North), to ensure a good geographic spread. The levels of Ramularia disease were variable across sites, with low levels in the Borders and moderate on the Fife and Aberdeenshire sites.

Bridgeway helped to reduce Ramularia infection and increased green leaf area, particularly in mix with Arizona.

Treatments rates and application timings

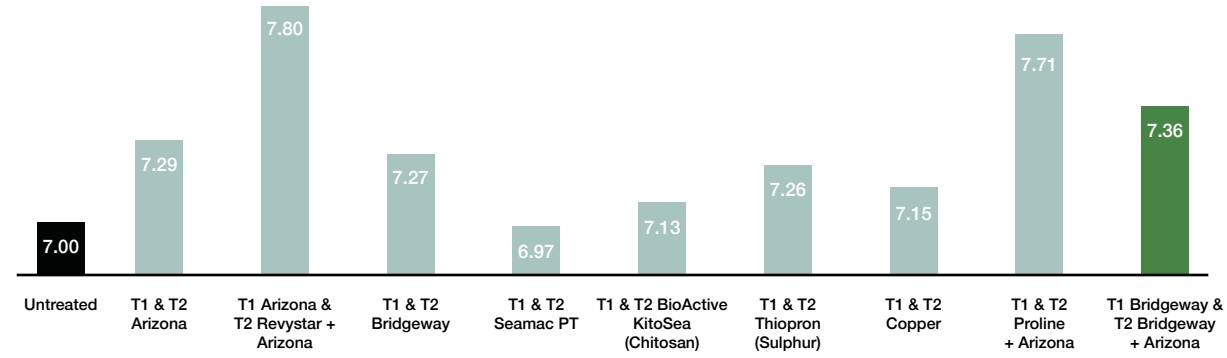
Site	Timing 1	Timing 2
South Central North	28/05/2021 27/05/2021 07/06/2021	18/06/2021 17/08/2021 29/06/2021
Growth Stage	GS 26-31	GS 39-49
1 - Untreated	Untreated	Untreated
2 - Arizona	Arizona 1.5 L/ha	Arizona 1.5 L/ha
3 - Arizona + T2 Revystar	Arizona 1.5 L/ha	Revystar XE 0.75 L/ha Arizona 1.5 L/ha
4 - Bridgeway	Bridgeway 2.0 L/ha	Bridgeway 2.0 L/ha
5 - Seamac	Seamac PCT 2.5 L/ha	Seamac PCT 2.5 L/ha
6 - Chitosan	BioActive KitoSea 4 L/ha	BioActive KitoSea 4 L/ha
7 - Sulphur	Thiopron 5.0 L/ha (UPL Liquid)	Thiopron 5.0 L/ha (UPL Liquid)
8 - Copper	Cuprokylt 2 kg (Liquid Copper 2.3 L/ha)	Cuprokylt 2 kg (Liquid Copper 2.3 L/ha)
9 - Standard Fungicide	Proline 275 0.2 L Arizona 0.74 L/ha	Proline 275 0.35 L Arizona 1.5 L/ha
10 - Bridgeway + T2 Arizona	Bridgeway 2.0 L/ha	Bridgeway 2.0 L Arizona 1.5 L/ha

Efffect of treatment on Ramularia infection (%) 2021, 3 site average in spring barley c.v. Laureate



Source: Scottish Agronomy 2021. Trials Results for Mains of Loirston Trust in Spring Barley. Evaluation of non-fungicidal novel options for treatment of Ramularia in Spring barley – 2021 results. Final assessment. Work funded by Mains of Loirston Charitable Trust.

Efffect of treatment on yield (t/ha) 2 year, 3 site average in spring barley c.v. Laureate



Source: Scottish Agronomy 2021. Trials Results for Mains of Loirston Trust in spring barley. Evaluation of non-fungicidal novel options for treatment of Ramularia in spring barley – Mean of 2020 & 2021 results. Work funded by Mains of Loirston Charitable Trust.

Key takeaways

- The highest yielding treatments on all 3 sites were those containing conventional fungicides – Arizona + Revystar XE and Proline + Arizona, this reaching statistical significance on the Borders and Aberdeenshire sites.
- These treatments also resulted in the greatest reduction in Ramularia infection across the three sites.
- The non-systemic treatments containing Arizona tended to contribute to a lesser reduction in Ramularia and marginal increase in yield.
- By reducing abiotic stress, Bridgeway decreased ramularia infection and increased green leaf area compared to the untreated – this was significant at the central site.
- Bridgeway increased yield at all 3 sites compared to the untreated, although this was not statistically significant.
- Where Arizona was combined with Bridgeway there was an improvement in yield in 2020 and 2021 trials, although this was not significant.
- Work continues into 2022.

Straight Bridgeway was included at T1 and T2 for trials purposes. Interagro does not recommend straight Bridgeway instead of fungicide for disease control.

NIAB trials in 2020 showed Bridgeway has a role to play in moderate-high input varieties

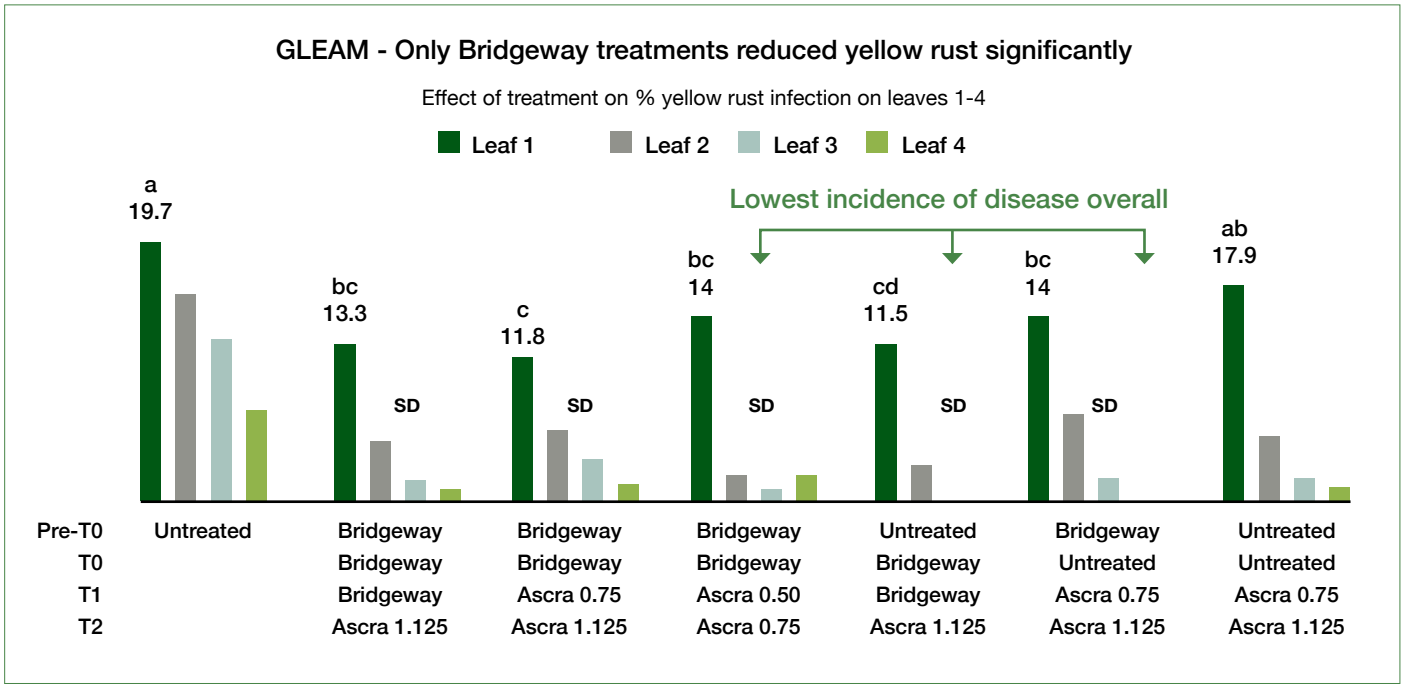
It is well reported that some biostimulants have host defence trigger properties, meaning they can improve the resilience of the host plant to disease infection. To have the maximum effect on the host defence mechanism, biostimulants should be applied in advance of disease attack i.e. at pre-T0 and at T0. Variety trials at NIAB in 2020 showed that Bridgeway significantly reduced yellow rust infection and increased yield and margin over input cost in low and medium disease resistant varieties, whereas high disease resistant varieties showed a flat response.

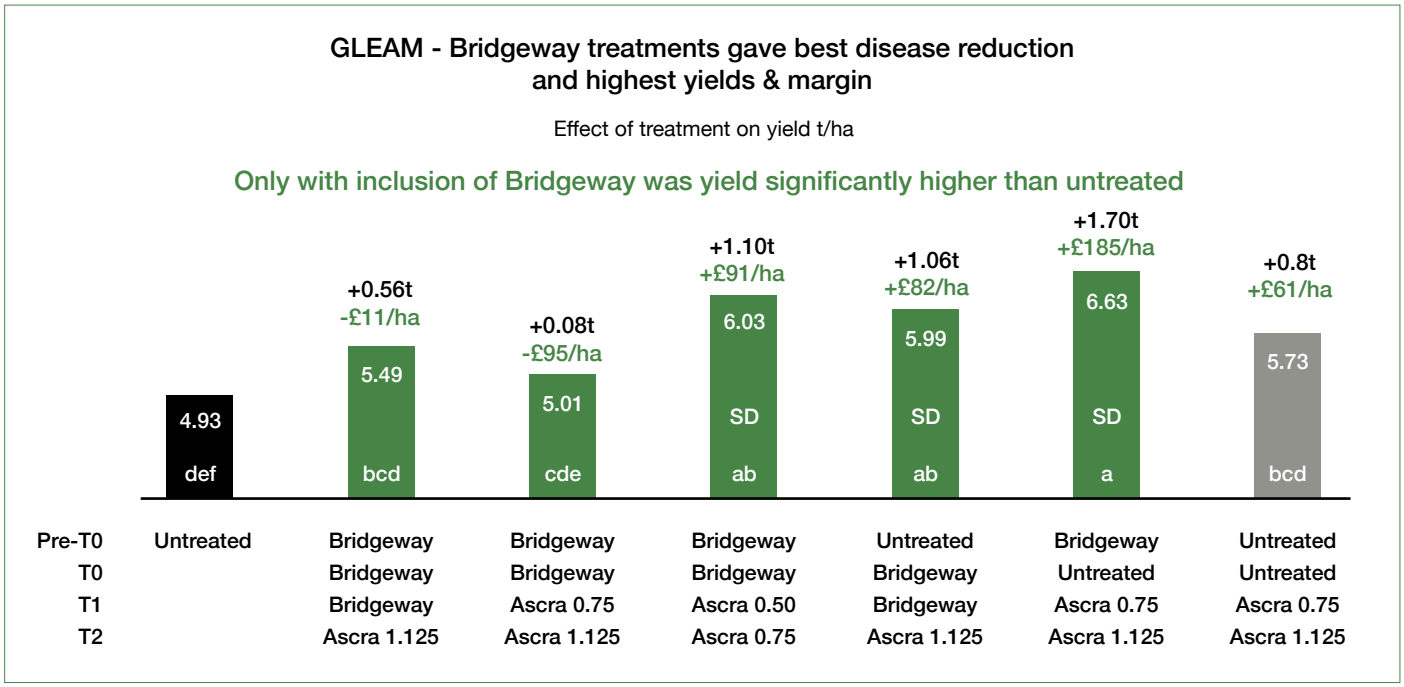
3 variaties were selected to test:

- **RGT Gravity** - low disease resistance, high fungicide input
- **Gleam** - moderate disease resistance, moderate fungicide input
- **KWS Extase** - high disease resistance, low fungicide input

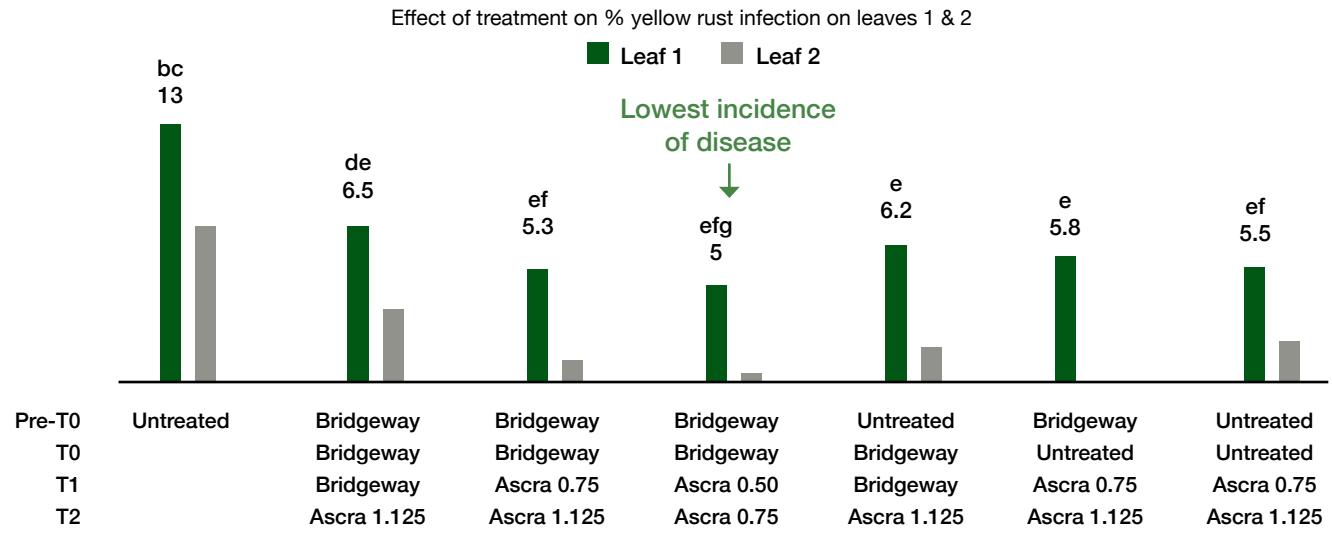
3 Bridgeway (2L/ha) application timing to test:

- **Pre-T0**
- **T0**
- **T1**





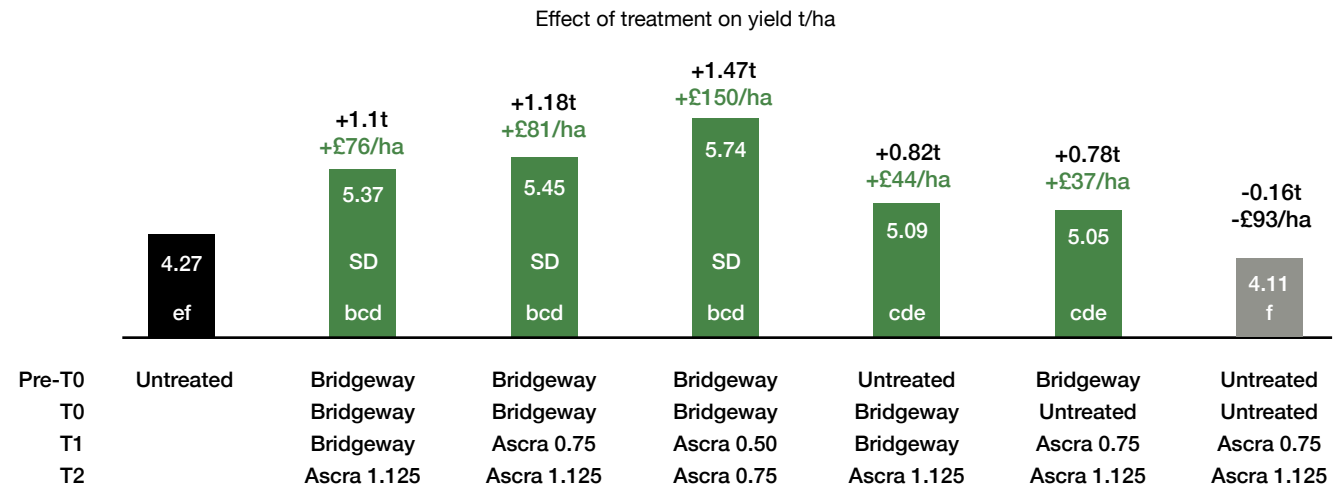
GRAVITY - Inclusion of Bridgeway at pre-T0+T0 gave the best reduction in % yellow rust infection



Key takeaways

- Bridgeway pre-T0+T0 was more effective than single applications at pre-T0 or T0 but not significantly
- All treatments reduced yellow rust infection significantly over the untreated.
- Bridgeway pre-T0+T0 gave the best overall reduction of yellow rust.

GRAVITY - Inclusion of Bridgeway pre-T0+T0 gave highest yields and margins

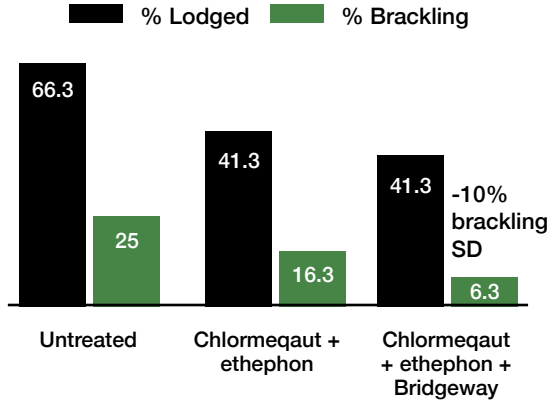


Key takeaways

- Only where Bridgeway was included were yields higher than the untreated.
- The highest yield and margins was achieved where Bridgeway was included at pre-T0+T0 and Ascra rate was reduced at T1 and T2.
- Only where Bridgeway was included at pre-T0+T0 were yields significantly higher than the untreated
- Fertiliser and crop protection products can stress the crop and this is the likely reason why Ascra only treated crop yield (without Bridgeway), was reduced.

Significant reduction in brackling

Bridgeway has been shown to reduce brackling in both winter barley and spring barley when applied with PGR. A replicated field trial was set up in winter barley in 2020 to further investigate the benefits of using Bridgeway 1.0 L/ha to reduce PGR stress on the crop at T2



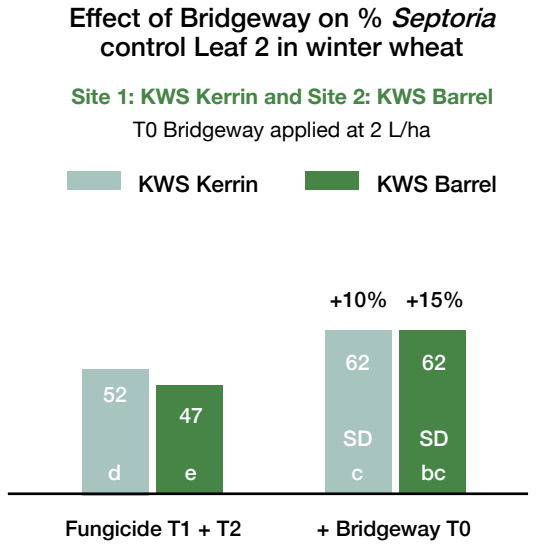
2020. UK. Winter barley KWS Gimlet. Applied at GS37. Part of a standard PGR programme. Lodging NSD, Brackling LSD 18.09.

Key takeaways

- PGR + Bridgeway resulted in less lodging than PGR only treatment - the difference was not significant.
- Yields were statistically higher than untreated crops.
- Bridgeway reduced brackling by 10% compared to PGR alone, which was statistically significant over the untreated
- Bridgeway increased yield by +0.13 t/ha over PGR alone.

Building plant health early provided significant benefits later

Replicated field trials by Prime Crop Research in 2021 looked at the effects of T0 Bridgeway applications on *Septoria.* The trial was set up in winter wheat KWS Kerrin and KWS Barrel on two separate sites. A standard T1 and T2 fungicide programme of Aviator + Arizona fb Elatus Era + Arizona was applied to both varieties.

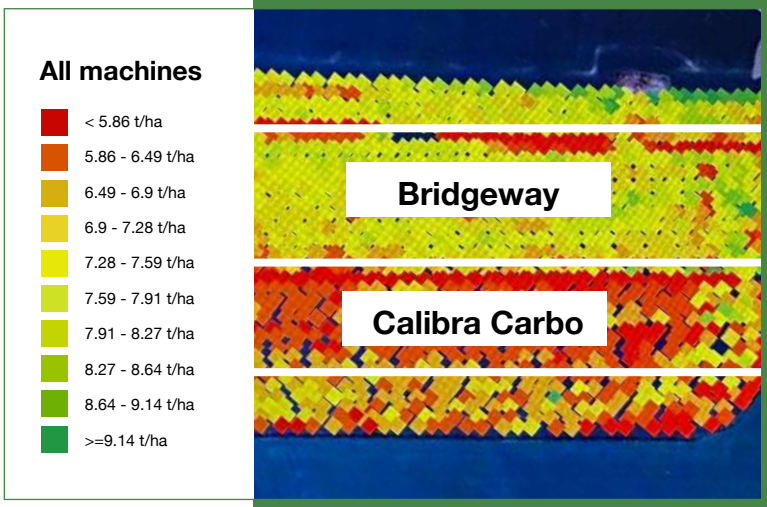


Prime Crop Research 2021 - Wyken, Suffolk. cv Barrel. Untreated 25.3% on 7th July. Standard Fungicide programme: Aviator 1L + Arizona 1L fb Elatus Era 0.8 + Arizona 1L

Prime Crop Research 2021 - Fulbourn, Cambridgeshire cv Kerrin. Untreated 19.3% on 22nd June. Standard Fungicide programme: Aviator 1L + Arizona 1L fb Elatus Era 0.8 + Arizona 1L.
SD = Significant difference

Key takeaways

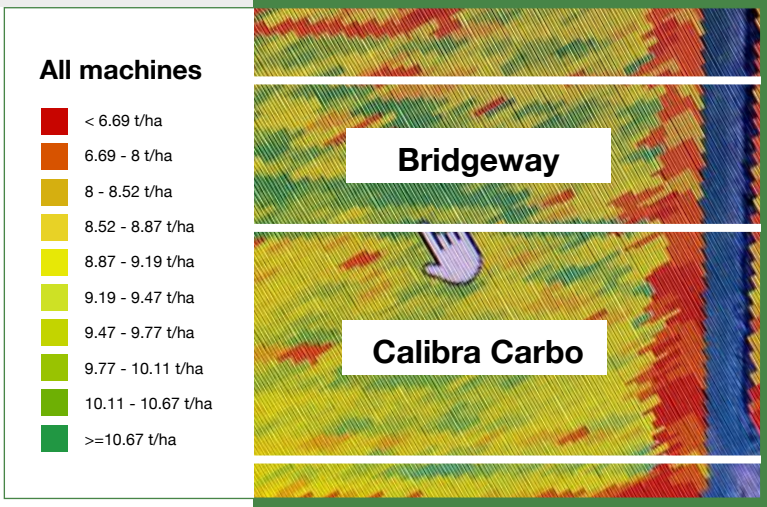
- In KWS Kerrin, fungicide at T1 + T2 gave 52% *Septoria* control on leaf 2 by the final assessment. In Barrel it was 47%.
- The addition of T0 Bridgeway helped improve plant health and biotic stress protection.



+1 t/ha over Calibra Carbo in W. Oats

A tramline trial was set up in 2020 in field of struggling winter oats cv Lineout, to assess the ability of biostimulants Bridgeway and Calibra Carbo to reduce stress. Both treatments were applied pre-T1 on the 15th May. Yields on the combine showed the Bridgeway treated tramline yielded > 1 t/ha more than Calibra Carbo.

Yield map and feedback courtesy of farmer. There were no visual differences in season.



+1 t/ha over Calibra Carbo in winter barley

On the same farm, Bridgeway and Calibra Carbo were also applied to separate tramlines in winter barley cv Valerie. The combine yield meter showed that Bridgeway increased yield over Calibra Carbo by >1 t/ha

Yield map and feedback courtesy of farmer. There were no visual differences in season.

Improved protection against abiotic stress in Cereals

Anti-stress

Following crop benefits 1 & 2 years on

Back in 2017 Bridgeway was investigated in tramline trials in winter wheat cv KWS Siskin. Bridgeway was applied as an additive to the fungicide programme at GS 31, 39 and 65, each at 2 L/ha. A base application of phosphate was also applied at GS30. The Bridgeway treated tramlines not only yielded an extra 3 t/ha, the stubble was also more golden due to improvements in plant health. Following the wheat harvest, an oilseed rape trial was planted in the field, and in the Bridgeway strip there was noticeable improvement in the rape, likely due to the recycling of nutrients from the wheat crop enhancing the oilseed rape. One year later and back into cereals, there was a noticeable reduction in liquid fertiliser scorch to the exact line where Bridgeway had been applied 2 years earlier (see image right).

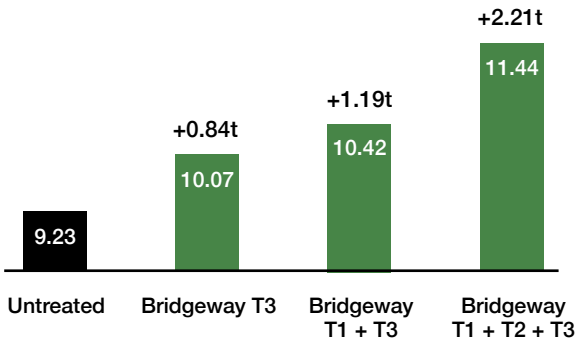
Source: Dick Neale, HL Hutchinsons, 2019.

Reducing stress increased yield

A tramline trial in feed wheat cv Relay was used to test the stress-busting capabilities of Bridgeway in 2018 - a year that was particularly stressful for crops. Three different tramlines were used to asses a single application, 2x applications and programme of 3x. The crop was stressed at T1 due to waterlogging and T2 was applied just before some very hot days. The crop was drought stressed at T3. All applications of Bridgeway helped to reduce stress in treated crops, with a signifcant yield increase as a result.

Effect of Bridgeway on yield (t/ha)

Tramline trials harvested over weighbridge



Source: Sally Morris, HL Hutchinsons 2018.

Improved plant health and yield in winter oilseed rape trials

Anti-stress

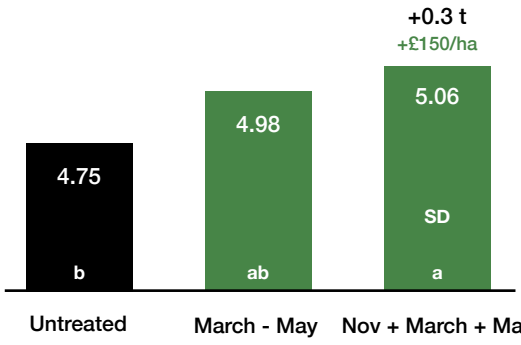
Higher yield and margins in WOSR

A replicated field trial was conducted in winter oilseed rape at Cropworks in Scotland in 2020 to assess the potential of Bridgeway to alleviate crop stress during the growing season and increase yield. Bridgeway applied in March and May increased yield but this was not significantly different to the untreated. Bridgeway applied 3x in the growing season increased yield significantly and increased margin over input costs by £150/ha.

Effect of Bridgeway on WOSR yield (t/ha)

All treatments applied at 2 L/ha

Cropworks Ltd.
Arable Trial Solutions



Cropworks Ltd, Perth, Scotland 2020. WOSR cv DK Exalte. Drilled 25th August 2019, harvested 21st August 2020. Bridgeway application dates - 5th November (GS 6 leaves unfolded), 20th March (GS flower buds enclosed by leaves), 5th May (GS mid flowering). Margin over input cost calculated using OSR price of £500/t and Bridgeway at £10/L. SD = Significant difference to untreated control.

Improved protection against abiotic stress in Potatoes

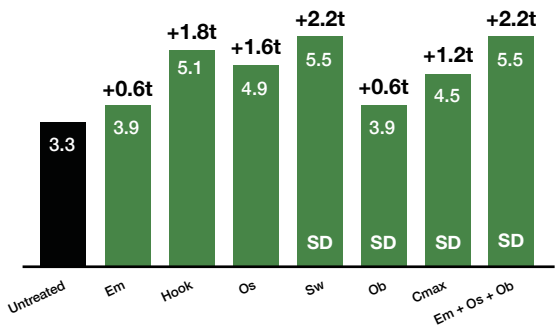
Anti-stress

Bridgeway protection against heat stress has been well proven in trials 2017-19

Potato productivity is greatly reduced at temperatures above the optimum of 20°C. The earlier in the season heat stress occurs, the more negative its impact on growth and yield. At 25°C tuberisation can be delayed, at 30°C it can stop altogether. Replicated field trials at CMI Ltd 2017-2019 have shown that Bridgeway helps to minimise the effect of temperature and moisture stress on the crop, and enables photosynthesis and tuberisation to be maintained even under very high temperature duress.

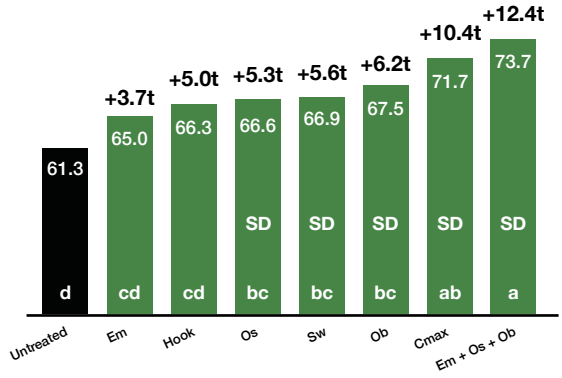
All Bridgeway applications increase tuber bulking

Effect of Bridgeway on tuber bulking (t/ha per week)



All Bridgeway applications increased tuber yield

Effect of Bridgeway on tuber yield (t/ha)



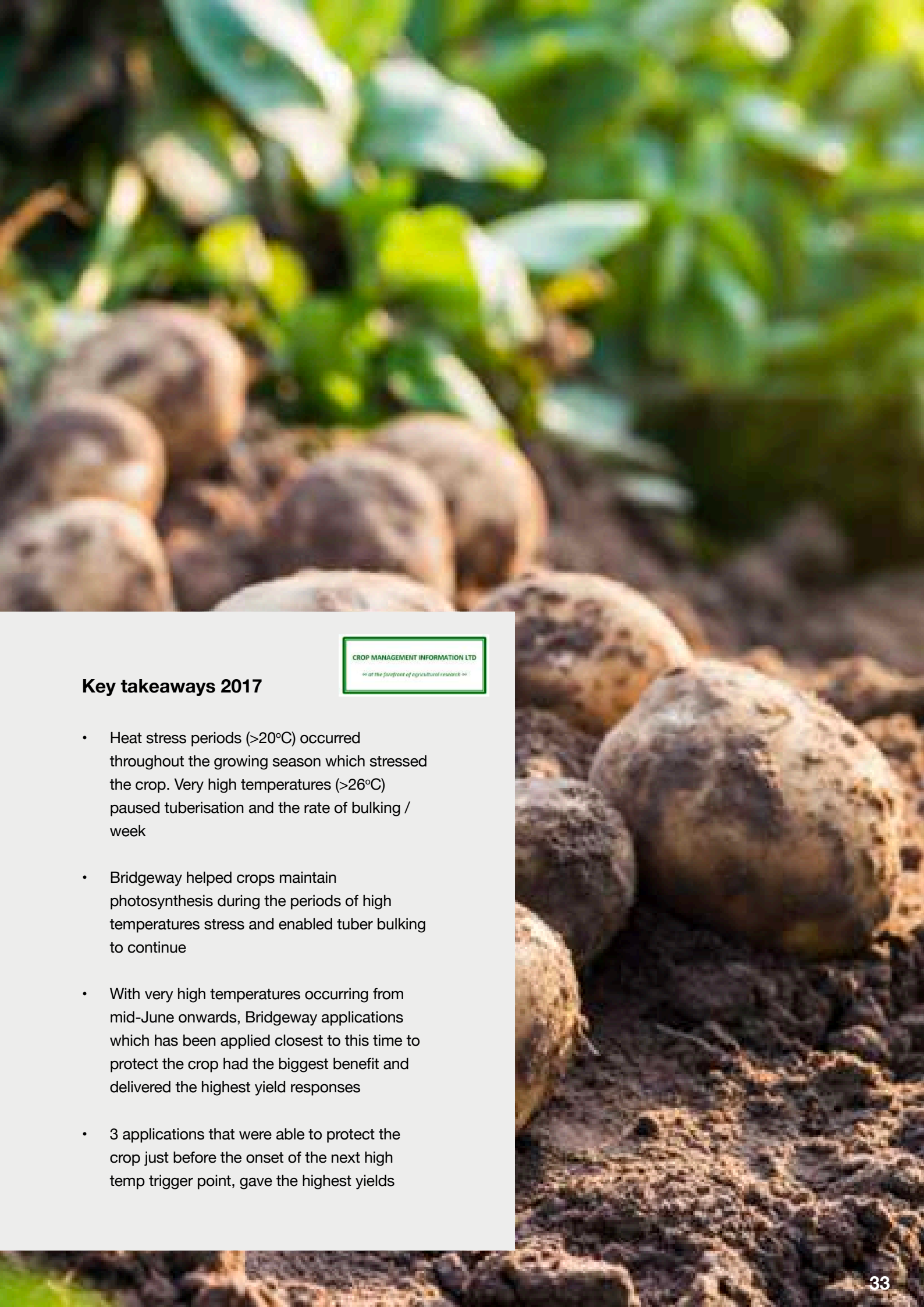
2017 cv Desiree. Yield assessment P=0.0007. SD = Significant difference to untreated control. Bridgeway applied at 2.0 L/ha per application

Bridgeway application timings

Application	Growth stage of application	Application date
Em	95% emergence < 5cm tall	9th June
Hook	Stolons extending, tips hooked	14th June
Os	Onset of stolon tip swelling, 1st visible tip swelling	22nd June
Sw	Mid stolon tip swelling, stolon tips swelling, <10mm	28th June
Ob	Onset of tuber bulking, first tubers > 10mm	7th July
Cmax	Max. canopy size, mid tuber bulking / onset of senescence	20th July

Temperature data - Lincolnshire trial area

Month	Date >20°C (above optimum, every 5°C above can decrease photosynthesis by 25%)	Date >26°C (delay in photosynthesis, tuberisation inhibited)	No. of stressful days
June	1st, 10th, 13th, 14th, 15th, 16th	17th, 18th, 19th, 21st	10
July	1st-5th, 7th, 8th, 15th-19th, 21st, 22nd, 26th	6th, 9th, 17th	16
August	1st, 3rd, 14th-17th, 22nd, 23rd, 25th-27th	28th	15



Key takeaways 2017

- Heat stress periods (>20°C) occurred throughout the growing season which stressed the crop. Very high temperatures (>26°C) paused tuberisation and the rate of bulking / week

- Bridgeway helped crops maintain photosynthesis during the periods of high temperatures stress and enabled tuber bulking to continue

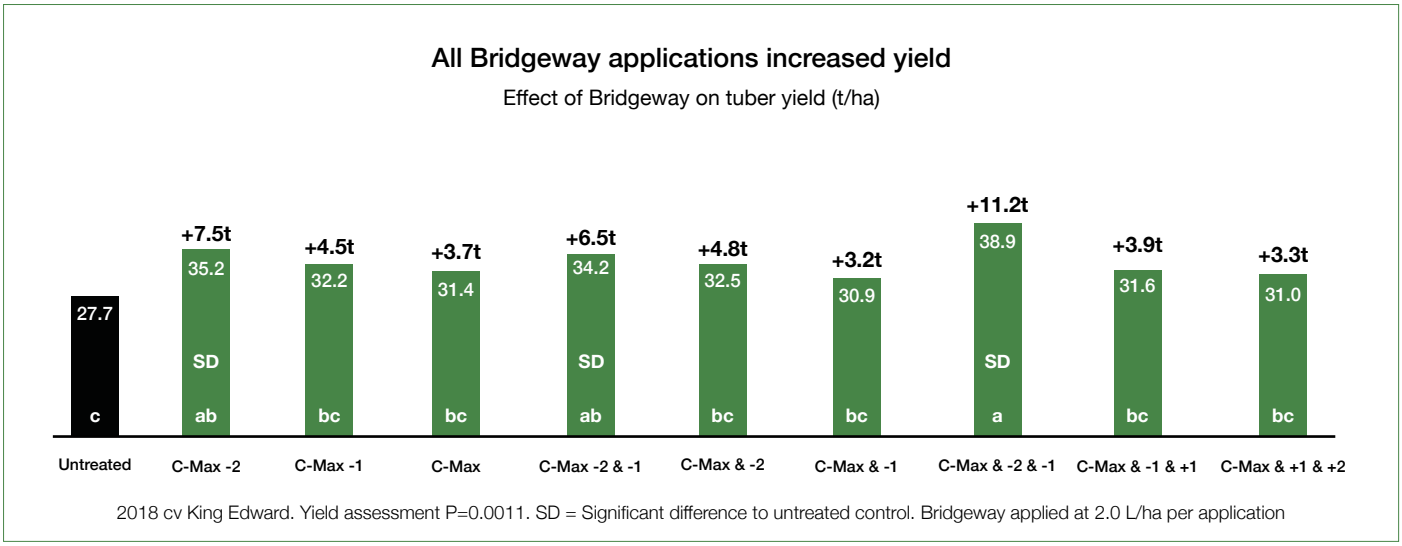
- With very high temperatures occurring from mid-June onwards, Bridgeway applications which has been applied closest to this time to protect the crop had the biggest benefit and delivered the highest yield responses

- 3 applications that were able to protect the crop just before the onset of the next high temp trigger point, gave the highest yields

2018

Bridgeway increased yield - 3 applications optimal

2018 trials investigated Bridgeway timings around full canopy (CMax) – up to 2 weeks before and 2 weeks after



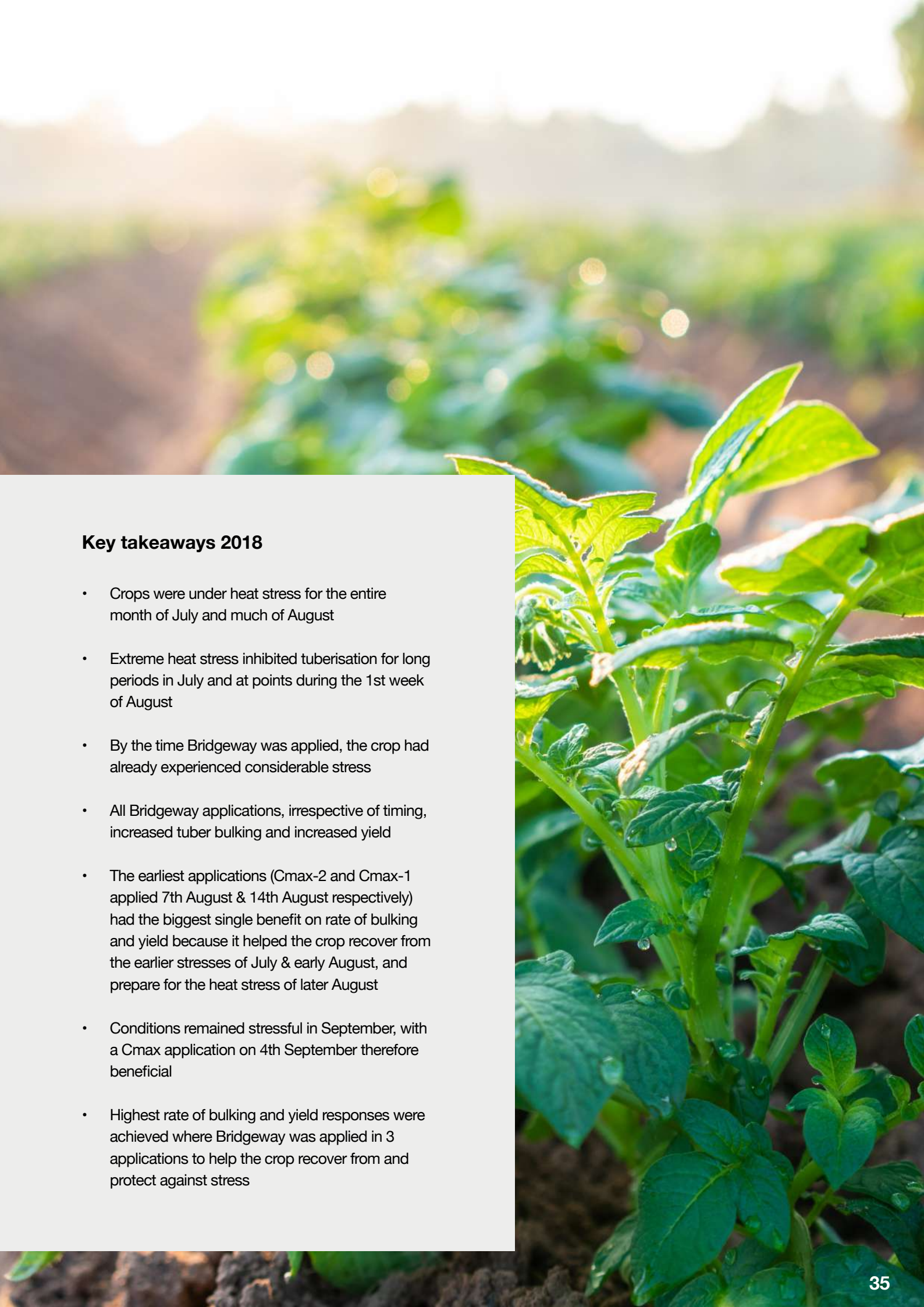
2018 cv King Edward. Yield assessment P=0.0011. SD = Significant difference to untreated control. Bridgeway applied at 2.0 L/ha per application

Bridgeway application timings & dates

Growth Stage	Application Date
2 Weeks before C-Max	7th August
1 Week before C-Max	14th August
C-Max	4th September
1 Week after C-Max	19th September
2 Weeks after C-Max	25th September

Temperature data - Lincolnshire trial area

Month	Date >20°C (above optimum, every 5°C above can decrease photosynthesis by 25%)	Date >26°C (delay in photosynthesis, tuberisation inhibited)	No. of stressful days
June	1st-4th, 9th-13th, 17th, 18th, 21st	5th-8th, 14th-16th, 19th, 20th, 22th-27th, 30th	28
July	1st, 4th, 8th, 11th-15th, 18th-22nd	2nd, 3rd, 5th-7th	18
August	1st-3rd, 17th-19th, 26th, 27th		8



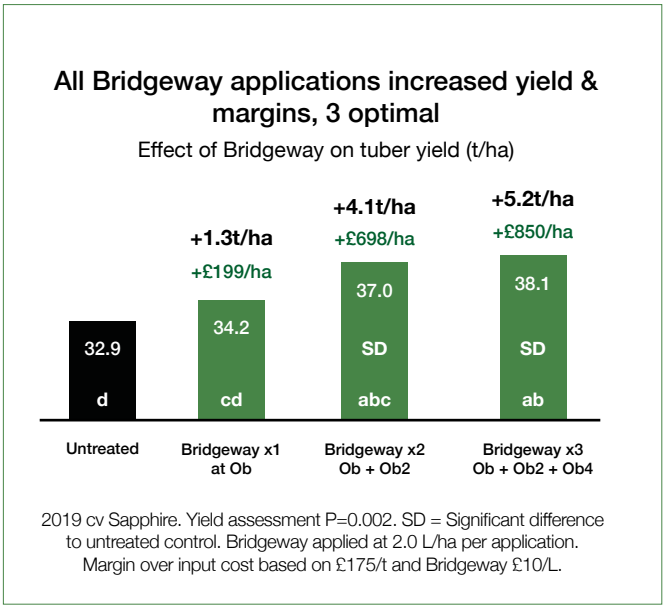
Key takeaways 2018

- Crops were under heat stress for the entire month of July and much of August
- Extreme heat stress inhibited tuberisation for long periods in July and at points during the 1st week of August
- By the time Bridgeway was applied, the crop had already experienced considerable stress
- All Bridgeway applications, irrespective of timing, increased tuber bulking and increased yield
- The earliest applications (Cmax-2 and Cmax-1 applied 7th August & 14th August respectively) had the biggest single benefit on rate of bulking and yield because it helped the crop recover from the earlier stresses of July & early August, and prepare for the heat stress of later August
- Conditions remained stressful in September, with a Cmax application on 4th September therefore beneficial
- Highest rate of bulking and yield responses were achieved where Bridgeway was applied in 3 applications to help the crop recover from and protect against stress

2019

Bridgeway increased yield under heat stress - 3 applications optimal

2019 trials investigated the impact of application number on yield and margins.



Key takeaways 2019

- Temperatures exceeded the optimum of 20°C throughout July and August.
- A single application of Bridgeway applied on 5th July to crop already under stress helped.
- With regular heat stress events and periods of excessive heat that inhibited tuber bulking, further top ups on Bridgeway were needed to kick-start photosynthesis and enable bulking to restart and made a significant difference to the overall yield and margin over input cost.
- Three applications delivered the highest benefit to yield.

Bridgeway application timings

Growth Stage	Application Date
Ob = Onset of tuber bulking	5th July
Ob2 = Onset tuber bulking + 2 weeks	14th August
Ob4 = Onset of tuber bulking + 4 weeks	4th September

Temperature data - Lincolnshire trial area

Month	Date >20°C (above optimum, every 5°C above can decrease photosynthesis by 25%)	Date >26°C (delay in photosynthesis, tuberisation inhibited)	No. of stressful days
July	4th, 5th, 10th-12th, 15th-17th, 20th, 21st, 26th, 29th, 30th	22nd-25th	16
August	1st-11th, 17th, 18th, 21st, 22nd, 28th, 30th, 31st	23rd-27th	23

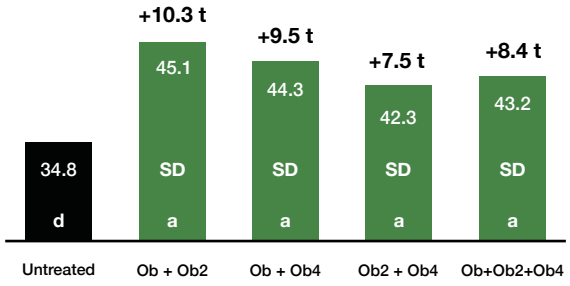
Green Crop Information
A branch of Dyson Farming

Stress-busting benefits of Bridgeway confirmed for 4th year

2021 trials by Green Crop Information at Dyson Farms repeated earlier work looking at optimal application timing. The early start of the growing campaign got off to a good start, but a period of heat stress (>25°C) started mid July.

All Bridgeway applications increased yield significantly

Effect of Bridgeway on tuber yield (t/ha)



2021 Green Crop Information, Nocton, Lincolnshire. Potatoes cv Sagitta. Yield assessment P=0.0100 18th August. SD = Significant difference to untreated control. Bridgeway applied at 2 L/ha.

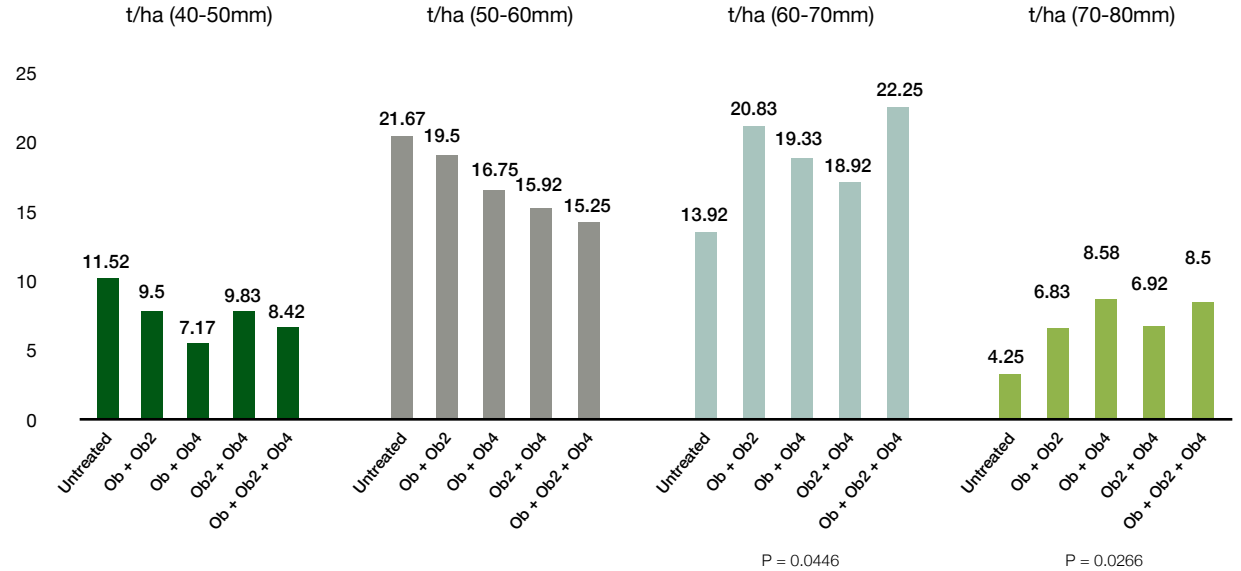
Bridgeway application timings

Growth Stage	Application Date
Ob = Onset of tuber bulking	30th June
Ob2 = Onset tuber bulking + 2 weeks	6th July
Ob4 = Onset of tuber bulking + 4 weeks	21st July

Key takeaways 2021

- A period of heat stress began mid July, after which, the rate of tuber bulking declined in untreated plots.
- Bridgeway enables bulking to continue during heat stress.
- All Bridgeway applications showed higher rates of bulking compared to untreated before and after the main heat stress period.
- All Bridgeway applications increased yield.
- Improved bulking compared to untreated lead to greater yields at top end of 40-80mm grade.
- Still proving earlier burndown possible.

Effect of Bridgeway on graded tuber weights (t/ha) – December lift



Potatoes love Bridgeway

Stress-busting biostimulant Bridgeway has proven highly effective over the last 4 years in helping commercial crops of potatoes to cope better with abiotic stress.

Bridgeway helped frosted potatoes recover yield

Alongside the sub-zero conditions of spring 2020, May's frosts caused severe damage to early and maincrop potatoes in some low-lying areas of the country. Some crops were set back weeks, with yield and lifting dates also badly affected. On this farm in Shropshire, Bridgeway was applied at the start of tuber bulking to help the crop recover from the harsh frost which had almost wiped it out.

Frost damage potatoes in Shropshire

Bridgeway treated - 14 days later

12 - 15% yield increase

Two weeks later the crop had recovered (see above). Two further Bridgeway applications were made, in with the next two blight sprays. The grower reported a 12-15% increase in yield from his Bridgeway treated potatoes.

+13% yield +£1,110/ha margin

In a second field in Shropshire test digs during August revealed a 13% increase in potato yields from plants treated with Bridgeway compared with untreated crops (table 1, below). Based on a crop yield of 45 t/ha, that's a yield increase of 5.85 tonnes per hectare and a margin over input cost of £1,110 per hectare.

Table 14. Effect of Bridgeway on potato yields - Shropshire field 2

Test Digs	Dig 1	Dig 2	Average	Difference
Untreated	8.29kg	9.99kg	9.14kg	
Bridgeway	10.35kg	10.32kg	10.34kg	+13.07%

+32% yield +£2,208/ha margin

In a third field is a Shropshire test digs in August showed a 32% increase in potato yield from applying Bridgeway (table 2, right). On a yield of 35 t/ha that's an extra 11.34 t/ha and an increased margin over input cost of £2,208 per hectare. Margins based on potato price of £200 per tonne.

Table 15. Effect of Bridgeway on potato yields - Shropshire, field 3

Test Digs	Dig 1	Dig 2	Average	Difference
Untreated	5.48kg	5.75kg	5.615kg	
Bridgeway	7.28kg	7.59kg	7.435kg	+32.4%

Bridgeway 2 L/ha applied at tuber initiation and again with the next 2 blight sorays. Test digs carried out in Shrophshire on 11th August. Field 2 cv Maris Piper, field 3 cv Roal

+8.15t/ha +£1,570/ha margin

Bridgeway was applied in a grower tramline trial in Fife to investigate the reported stress-relieving benefits. in 3 test digs conducted in August 2020, the grower calculated that Bridgeway increased yield by 8.15 t/ha (table below) which is a margin over input cost of £1,570 per hectare

Test Digs	Untreated	Untreated
Dig 1	16.25kg	19.82kg
Dig 2	21.95kg	23.25kg
Dig 3	18.63kg	22.81kg
Average	18.94kg	21.96kg
Yield/ha	50.64t/ha	58.79t/ha
Difference		+8.15t/ha

19th August 2020. Maris Piper. Fife. Test digs were 2m beds (2 rows). Yield calculated by Grower based on bed width

Bridgeway key benefits summary

- Protects against temperature stress
- Enables tuber bulking to continue in stressful growing conditions
- Improves the production efficiency of the crop
- Enables burndown and potato lifting to start earlier compared to untreated crops
- 2 - 3 applications optimal for yield and margins

Improved protection against abiotic stress in Sugar Beet

Anti-stress

Recovery from herbicide damage

"Nothing short of a miracle"

in 2017 we got our first insight into the true magic abilities of Bridgeway. A sugar beet crop was under severe stress as a result of a herbicide contaminated spray tank. Bridgeway was applied in a last desperate attempt to save the crop.

Bridgeway was applied at 2.0 L/ha when 10-30% of plants were meeting in the rows. 15 days later, the crop was well on the way to recovery.

For the farmer and agronomist concerned, it was *"nothing but short of a miracle"*

For some of the beet, damage was just too severe, but for others, Bridgeway stimulated a new crown grown.

Herbicide damage

15 days later after Bridgeway treatment

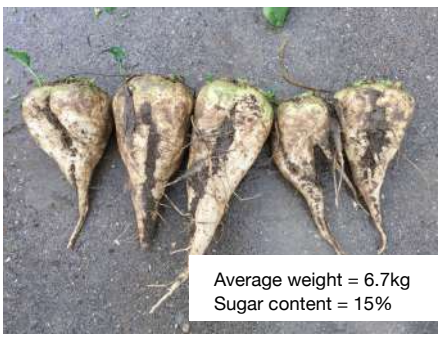
Some damage too severe

Bridgeway stimulated a new crown to grow

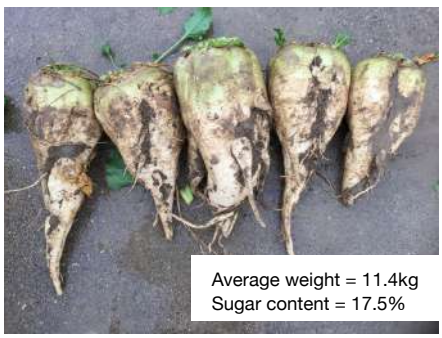
Bridgeway increased yield & sugars

Test digs in August revealed that Bridgeway not only increased the yield of the herbicide damaged beet, but also increased yield over undamaged, healthy beet too.

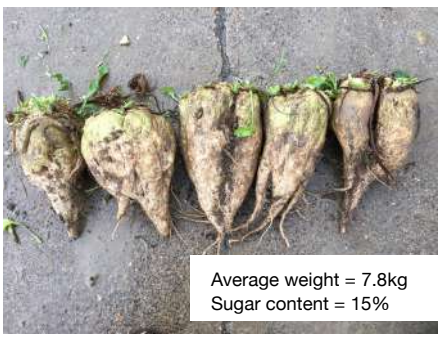
Bridgeway treated beet had higher yields and sugars relative to untreated tramlines - see results below from August test digs.



Untreated (healthy crop)



Bridgeway (healthy crop)



Bridgeway (damaged crop)

Yield increases in commercial crop

+23.4 t/ha, +0.5% sugars, +£418/ha margin

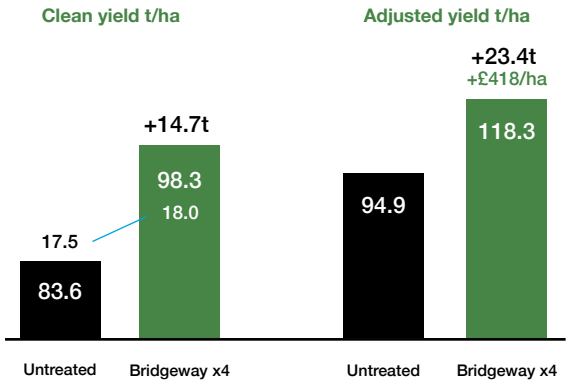
A tramline trial was conducted over 0.76ha in a commercial sugar beet crop in Stowmarket in 2019 to investigate the potential yield benefits of Bridgeway. Reduced rates of Bridgeway were drip fed over 4 applications during the rapid growth of the crop. Treatments were made with insecticide to manage virus yellows, with Mn or as a solo application. Test digs were conducted in different parts of the field, just before lifting the field.

Bridgeway application timings

1.25 L/ha applied in 400 L/ha water at:
4 true leaves
6-8 true leaves
12 true leaves
12+ true leaves

Yield, sugar and margin gains

Effect of Bridgeway on sugar beet yield (t/ha)



Source: Agronomist, 2019. SD = Significant difference to untreated.

Key takeaways

- Soyl biomass imagery detected no canopy differences between treated & untreated plant.
- Test digs revealed Bridgeway was working below ground on yield and sugars.
- Sugars were sampled by British Sugar.
- Untreated beet had a clean yield of 86.3 t/ha (adjusted 94.9 t/ha) with sugar at 17.5%.
- Bridgeway treated beet yielded 98.3 t/ha (adjusted 118.3 t/ha) with sugar at 18% - a 23.4 t/ha increase.
- Margin over input cost was +£418/ha.

Consistent yield increases in replicated trials

Significant yield and margin responses in stress & non-stress situations

During 2018 and 2019, CMI Ltd investigated the effect of biostimulant Bridgeway in commercial sugar beet crops to define optimum stages and sequences for the use of biostimulants. The growing season of 2018 provided an ideal opportunity to study application of amino acid solutions to a crop that was to become stressed by heat and potential water shortage. The experiment site was drilled into moist conditions after a wet spring, but the month of June proved very hot and below average rainfall. July and August followed similar trend. In 2019 the opposite was true with above average rainfall.

Bridgeway application timings

2TL = 2 true leaves

4TL = 4 true leaves

6TL = 6 true leaves

3 timings = 2+4+6 true leaves

% = sugars

Trials 2018 & 2019

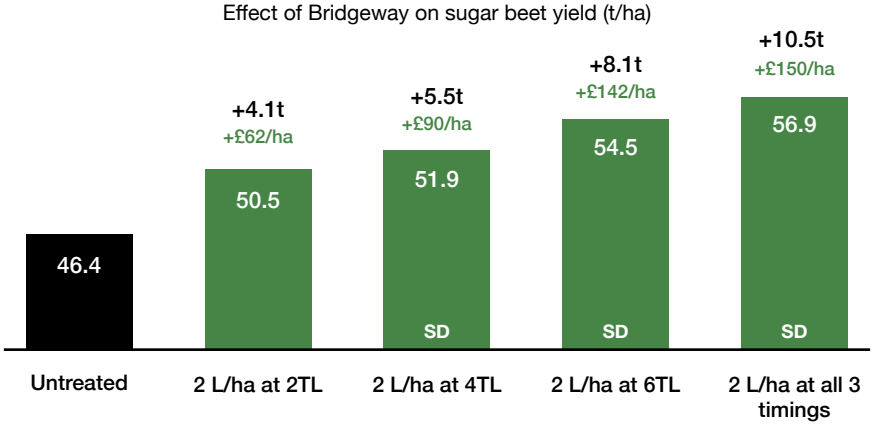
2019 Yield assessment P=<0.005. 2018 Yield assessment P=0.0011. SD = Significant difference to untreated control. Bridgeway applied at 2.0 L/ha per application. Margin over input cost based on £20/t and Bridgeway £10/L.

Trials 2021

Green Crop Information Sugar Beet trial cv KWS Kortessa 2021. Nocton, Lincolnshire, UK. Harvested 10th Dec. Unusually high yields so yield data represented as % over untreated. SD = Significant difference to untreated. Adjusted to 16% sugar.

2018 trial showed 3 applications optimal

Effect of Bridgeway on sugar beet yield (t/ha)

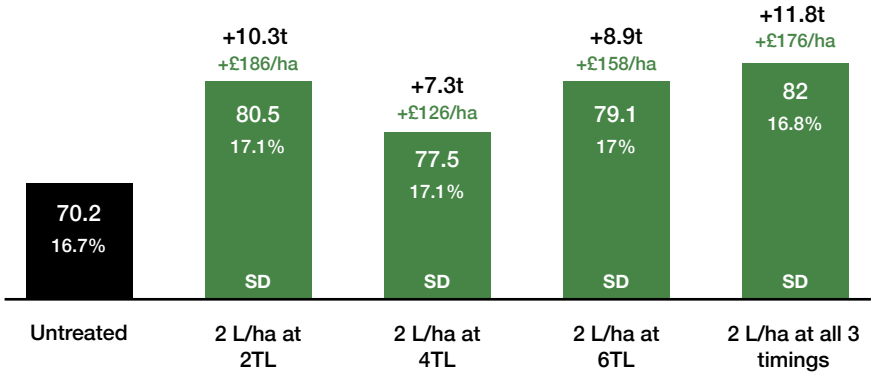


Key takeaways 2018

- In a drought stress year, Bridgeway helped the crop coper better with stress.
- No visual or green scan differences in season.
- Above ground was no indication of below ground.
- Bridgeway pushed bulking early on.
- Bridgeway increased beet yield at all timings.
- Yield were significantly higher from 4TL onwards.
- Highest yields and margins came from 3 applications.
- Nutrient analysis showed increases in zinc concentration in Bridgeway treated plants.

2019 trial showed 3 applications optimal

Effect of Bridgeway on sugar beet yield (t/ha) cv BTS1140 - adjusted



Key takeaways 2019

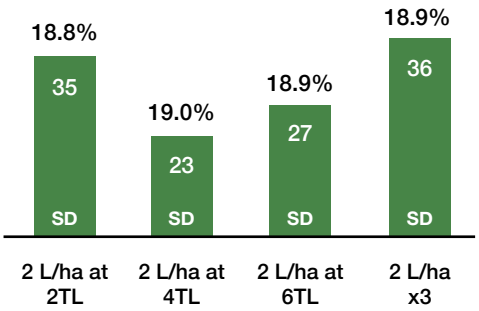
- With above average rainfall - no drought stress.
- No visual or green scan difference in season.
- Above ground was no indication of below ground, so the results were surprising.
- Bridgeway still increased yields significantly at all application timings.
- Bridgeway increased % sugars at 2TL, 6TL & at all 3 timings.
- Highest yield and margins came from 3 applications.

Stress-busting benefits of Bridgeway confirmed for 4th year

2021 trials by Green Crop Information at Dyson Farms repeated earlier work looking at optimal application timing. The early start of the growing campaign got off to a good start, but a period of heat stress (>25°C) started mid July.

2021 trial showed 3 applications optimal

Bridgeway adjusted yield benefit over untreated (%)



Key takeaways 2021

- Bridgeway increased yields significantly at all application timings
- All Bridgeway increased sugars over the untreated (18.6%)
- Highest yields and margins came from 3 applications

Bridgeway key benefits summary

- **Builds stress resilient beet crops eliminating threat to yield**
- **Speeds up tap-root bulking to maximise yield potential**
- **Increases the metabolic efficiency of the crop, leading to higher sugars**
- **3 applications optimal for yield and margins – 2TL, 4TL & 6TL**

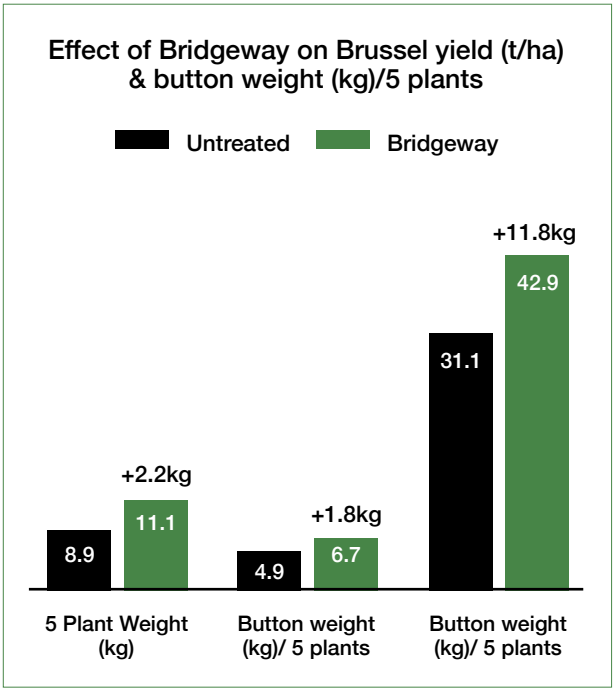
Improved plant health and yield in onion and brussel sprout trials

Rooting

Higher yield & quality in Brussel Sprouts

Bridgeway was put to the test in Brussel Sprouts at The Allium & Brassica Centre in 2018, where it increased plant health and overall yield. Bridgeway was applied at one rate of 2 L/ha and applied in 6 applications. In addition to improved rooting, there was a noticeable reduction in powdery mildew in plants treated with Bridgeway which led to an increase in plant weight, button weight and total yield. Bridgeway delivered the best overall yield of all biostimulants tested, with a calculated increase of 11.8 t/ha (+38%) over the untreated control.

Source: Allium & Brassica Centre, Boston 2018. Bridgeway 2 L/ha applied from 1st June in 6 applications. Control yields averaged over 6 plots. Final yield based on 32,000p/ha.



Bridgeway improved plant health leading to better disease resistance

Untreated

Bridgeway

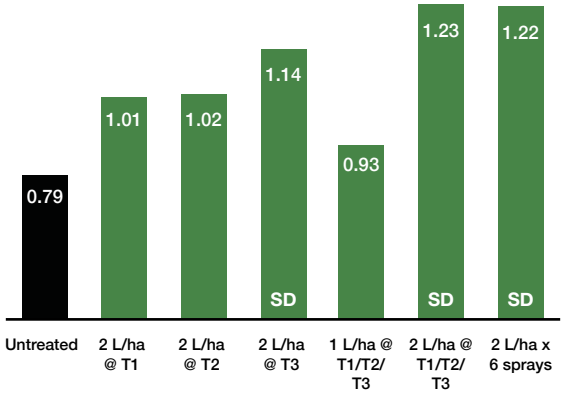
Higher yield in onions at all timings

Bridgeway trialled in maincrop onions by CMI Ltd in 2018 looked to define optimum growth stages and sequences. The onion growing season of 2018 proved problematic for numerous reasons: a very wet spring delaying drilling and establishment of spring crops, and a particularly hot, dry summer hastened senescence. The onions were very slow to emerge and subsequently grow. There were noticeable improvements in green leaf area and bulb size in plots treated with Bridgeway. Applications of 2 L/ha gave higher yields than 1 L/ha and 3 applications applied at 3-4 true leaves, 7-12 true leaves and bulb size at 2.5-5cm were optimal for yield.

Bridgeway application rates and timing

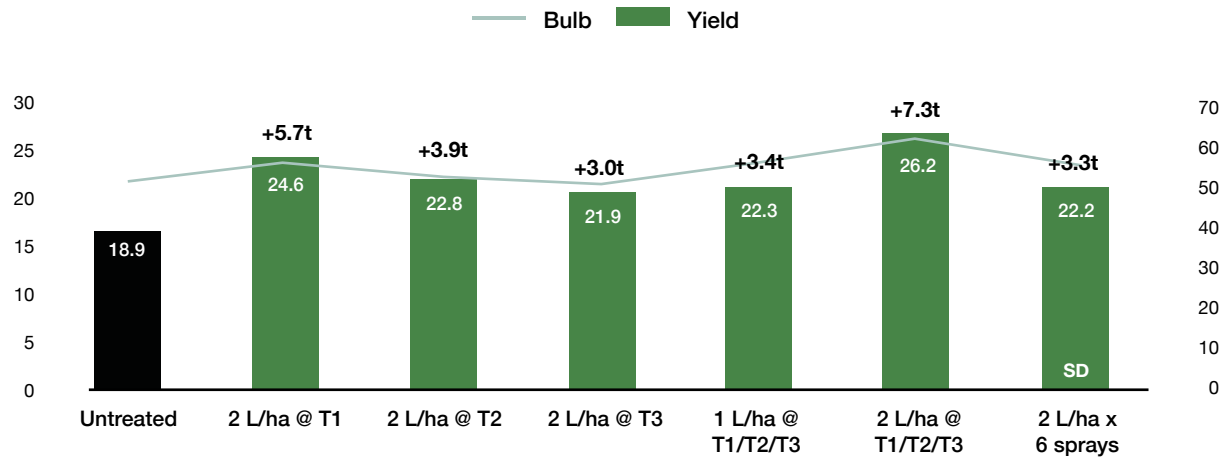
Bridgeway Timing	Onion growth stage	Dose rate per timing	Application Date
T1	3 - 4 true leaf	2 L/ha	22nd May
T2	7 - 12 true leaf	2 L/ha	13th July
T3	Bulb 2.5 - 5cm	2 L/ha	26th July
T1 + T2 + T3	All 3 timings	1 L/ha	9th August
T1 + T2 + T3	All 3 timings	2 L/ha	28th August
6 sprays	All 3 timings + more (10 - 14 day intervals)	2 L/ha	12th September

Effect of Bridgeway on onion green leaf area (GDVI)



GDVI scan assessed 6th September.
SD = significant difference to untreated.

Effect of Bridgeway on onion yield (t/ha) & g/bulb



CMI Whittlesey 2018. Onions NSD. Assessed 16th October.

Key takeaways

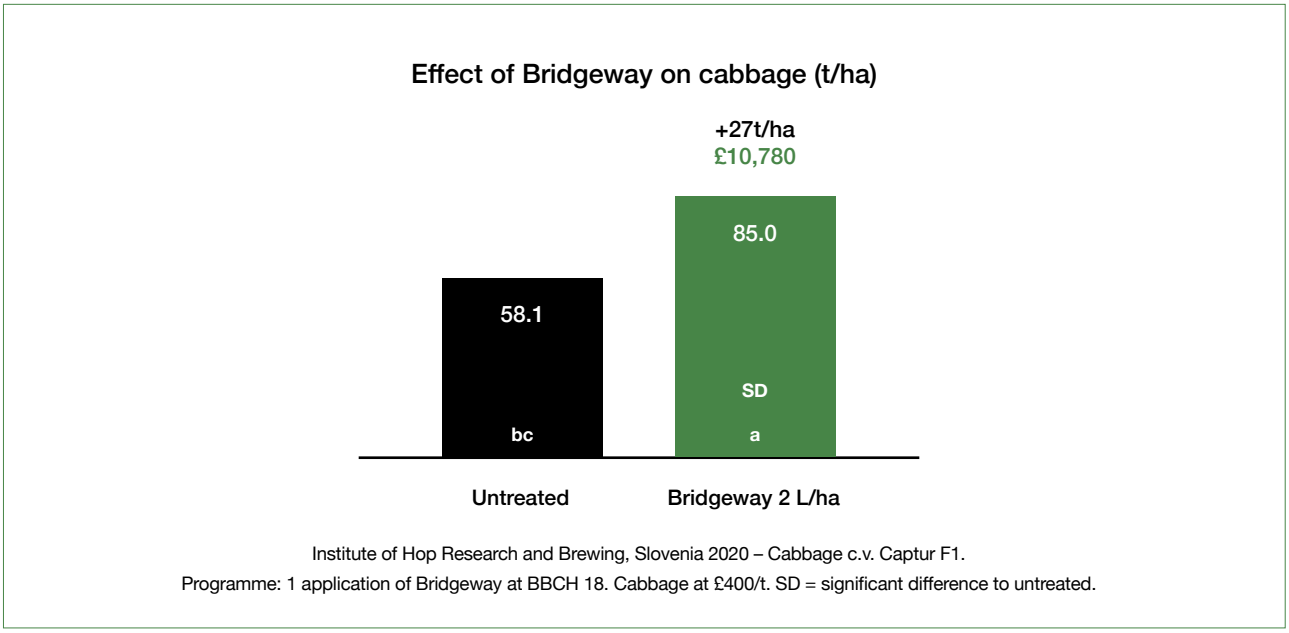
- All Bridgeway treatments increased green leaf area.
- All Bridgeway treatments increased onion weight and overall yield.
- There was a tendency for earlier treatments at 3-4 true leaves and 7-12 true leaves to produce the biggest yield increases.
- A later application at bulb diameter 2.5-5.0 cm, was made when the temperature was very high and drought conditions well established. This application was not as effective at increasing bulb weight. This may have been as much connected with timing according to the onset of stress.
- There was a tendency for multiple applications (up to three in this experiment) to increase weight of bulbs further; while increasing the number of applications to six had no further benefit.
- Calculated margin over input costs per hectare showed consideriable benefits from all Bridgeway applications.

Improved plant health in cabbage and swede

Rooting

Significantly higher yields in cabbage

Bridgeway was put to the test in cabbage at The Institute of Hop Research and Brewing in Slovenia in 2020. Plots were replicated and a single application of Bridgeway was applied at a rate of 2 L/ha at 8 true leaves. Bridgeway increased yield significantly, by 27 t/ha (+46%) over untreated plots and generated a calculated margin over input cost of £10,780/ha.

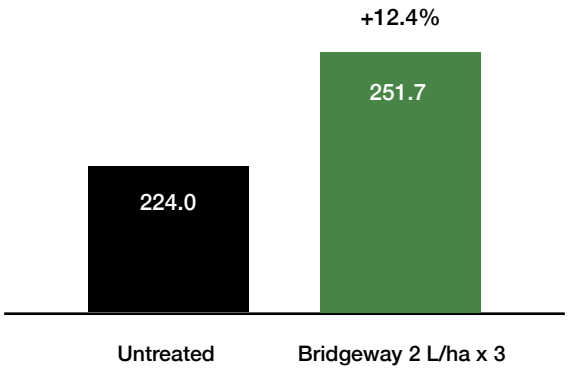


Institute of Hop Research and Brewing, Slovenia 2020 – Cabbage c.v. Captur F1.
Programme: 1 application of Bridgeway at BBCH 18. Cabbage at £400/t. SD = significant difference to untreated.

Plant health improvements seen in swede

ADAS trials in Fife in Scotland in 2020 assessed the benefit of Bridgeway applied to Swede at 3-4 true leaves with follow up applications at 6-8 true leaves and when foliage at 35cm height, root expanding. Growing conditions were optimal during the season. Samples taken from 4 replicates showed a yield increase of 12.4% over untreated plots. This was not statistically significant.

Effect of Bridgeway on main swede weight (g). Sampled from 4 replicates



ADAS Fife 2020. Swede biostimulant screen. Bridgeway applied at 2 L/ha at 3-4 true leaves on 2nd July, 6-8 true leaves on 6th August and when foliage at 35 cm in height on 28th August. Full destructive assessment 23rd September.

Bridgeway product and application information

Classification	Protein hydrolysate biostimulant
Composition	Vegetal amino acids and soluble peptides, 5% nitrogen, 17.8% biological organic carbon, minerals
Recommended crops	All agricultural and horticultural crops
Rates use by crop	Bridgeway is to be used at a rate of 1 – 2 litres per hectare, per application. Please find specific crop recommendations below.

Crop	Rate L/ha	Recommendations to support plant health
Cereals	1 - 2	Apply mid-tillering (pre-T0) and T0 in wheat. Apply at T1 and T2 in barley and oats.
Oilseed Rape	1 - 2	Apply at 4-6 true leaves, green bud and mid flowering.
Sugar Beet	2	Apply at 2, 4 and 6 true leaves.
Potatoes	2	Apply at stolon tip swelling, onset of tuber bulking and at full canopy.
Horticultural crops in general	2	Apply every 14 days from crop establishment. Target key stages of development or stress such as flowering, fruit set, tuber set.
Leafy vegetables	2	Apply 10 days after transplanting; before and after head set.
Orchards	1 - 2	Apply before each development stage. To enhance flowering and fruit set apply 21 and 7 days before flowering, and 4 and 14 days after petal fall.
Abiotic stress	1 - 2	For best results, apply 3-5 days before the onset of environmental stress. For stress recovery, apply as soon as possible.

Mixing	Shake the container well before use. Dilute the required quantity of Bridgeway in a minimum of 100 litres of water per hectare and apply as a foliar application to plants.
Compatibility	Bridgeway is compatible with the most common plant protection products and fertiliser. However, before use, we recommend testing for compatibility to avoid any doubt.
Pack size	10 litres
Storage	Store in a cool, dry location away from direct sunlight. Keep cap closed when not in use.

With Bridgeway

- Renewable, plant-based solution for growth stimulation, nutrient-use-efficiency and stress resistance
- Unique and innovative extraction process guarantees the highest purity
- Fast and effective adsorption that is 100% water soluble
- The most effective and efficient method of feeding amino acids to your plants
- Approved for use in organic systems by Organic Farmers and Growers and the Soil Association
- Class leading biostimulant on root and shoot growth*
- Backed by intense research

* Source: Growth stimulation trials conducted on winter wheat at The University of Nottingham in 2019. 10 replicates, 95% confidence limits.

Frequently asked questions

What is the function of amino acids and peptides in plants?

Amino acids and peptides are the building blocks of protein and are critical for healthy growth and development. They play a vital role in virtually every process within plants, including photosynthesis, regulating root and shoot growth, metabolic enzymes and stimulation, nutrient transport, stress defence and the regulation of crop growth. They are also responsible for the storage and transport of nitrogen and are therefore an important part of N metabolism. In abiotic and biotic stress conditions stress-busting amino acids are needed in high concentrations to provide tolerance and repair.

What is the optimal application timing for Bridgeway?

It depends on the purpose of the application. To protect against stress, we would recommend applying 3 - 5 days prior. To optimise root and shoot growth, this will be best achieved early and prior to stem extension.

On what crops can Bridgeway be used?

Bridgeway can be used on all agricultural, horticultural and ornamental crops throughout the growing phase in conventional and organic systems. It is approved by Organic Farmers and Growers for unrestricted use.

How long does it take for Bridgeway to work in the plant?

Bridgeway is rapidly absorbed by the leaves and translocated in plant tissue. Within a few hours it can perform its function in the plant.

There's lots of biostimulants on the market, why should I use Bridgeway?

Replicated lab, field and commercial trials have shown Bridgeway can add significant benefits to plants, particularly in suboptimal growing conditions. It is best in class on root and shoot growth and replicated field trials have shown consistent benefits in crops which are highly susceptible to abiotic stress, such as potatoes and sugar beet. We believe Bridgeway is the best source of amino acids and peptides for plants because it contains all plant-based L-amino acids needed by plants, with the most important ones in higher concentration than many alternative sources due to our cutting-edge enzymatic hydrolysis techniques. With an intense research programme behind it, there's a wealth of proof that Bridgeway can optimise productivity and margins.

Can I reduce my fertiliser rate by using Bridgeway?

The efficient provision of all L-amino acids in an immediately available and useable form, could offer the possibility to reduce the dependence on nitrate and ammonium fertiliser as an N source for amino acid and protein biosynthesis. Amino acids are responsible for the storage and transport of N in plants and are therefore an important component of N metabolism. Putting N metabolism to one side, optimising access and N uptake from the soil is one of the key benefits of Bridgeway as it helps to build more robust root systems, increasing both lateral roots and root length. This enables crops to capture available nutrients readily available in the soil and leached water and nutrients lower down. Supplementing crops with Bridgeway offers the potential to increase nutrient-use-efficiency. We are working with research partners at the moment to establish how far you can go.

What's the benefit of using an amino acid biostimulant like Bridgeway?

Plants expend considerable energy breaking nitrate and ammonium down into nitrogen to make amino acids and proteins. Applying an amino acid biostimulant provides the ready-made building blocks for protein biosynthesis. In good conditions this reduces the amount of energy the plant channels into protein production. Under stress conditions, it enables the plant to conserve energy and avoids the waste of breaking down proteins to recycle amino acids for stress defence. Applying an amino acid biostimulant early on also helps to build more robust root systems that can scavenge for water and nutrients, increasing fertiliser uptake and adds to the nutrient-use-efficiency benefit.

Will I always get a yield benefit?

No not always. One of the key benefits of applying Bridgeway is to increase the productivity of the crop, by increasing nutrient transport and increasing the rate of photosynthesis. If the raw materials (CO_2, water and sunlight) are missing for photosynthesis to take place, it will not be possible for crops to photosynthesise, slowing crop growth. CO_2 and sunlight are rarely a problem, but water could be. Optimising early rooting will certainly help crops access water deeper down if supply does become short in season. This will give Bridgeway the best chance of delivering higher yields if water deficit becomes an issue later.

How long will Bridgeway last in the crop?

Approximately 10-14 days. However, the effect could last far longer depending on application and growing conditions.

Testimonials

Jackie Cotton

Independent Crop Consultant

I've tried a number of different products, but the best results I've seen so far have been from using amino acids in fodder beet. Specifically, I used Bridgeway and saw a 7% yield increase. For me, this is a must-have in all fodder beet recommendations from now on.

I've been using Interagro's Bridgeway biostimulant for three seasons now, mainly on organic crops but also on some conventional ones too. Initially we used it on organic tenderstem broccoli and courgettes and have since extended it those two crops in conventional systems plus pumpkins and a little on sweetcorn. We have been using about 3 L/ha, split into more than one dressing, depending on the crop. Certainly, the organic crops treated with Bridgeway become noticeably brighter and more vibrant, and we get heavier yields. Our own company trials in the first year recorded a 25% yield improvement in organic tenderstem broccoli treated with Bridgeway, and in 2018 I would estimate a 10-25% average yield lift across all the treated crops – these are substantial improvements. The product keeps the crop greener for longer and allows it to make maximum use of the crop nutrition available - especially micronutrients – which is obviously important for organic crops. But without a doubt, it is effective on conventional crops too.

Neil Cairns, Crop Production Manager, Barfoots

Al Brooks

Director, Facombe Estates

A significant area of our HEAR OSR looked horrendous, and as a last resort, we thought we'd offer it a little TLC in the form of 2 L/ha of Bridgeway. It was a transformation. The plants took on an altogether different colour, becoming much greener. The smaller plants which had been looking particularly stressed, put out a more fibrous root system and the crop went from strength to strength. We repeated the application in Nov and one field in this area turned out to be the highest yielding of our OSR crop, at 5.1t/ha, against a farm average of 4.8t/ha.

Dr. Syed Shah

Agronomist, NIAB

With fertiliser prices being so high, some of the better biostimulant products may actually be worth putting budget towards. One of these is Bridgeway, and we've seen in our own trials the benefit this can have on rooting, for example. The yield benefit isn't always as obvious, but in a low fertiliser situation, if you have an enhanced rooting system that will allow plants to better scavenge the nitrogen available within the soil, it will help.

I first started using Bridgeway in 2018, initially to help combat plant stress in cauliflower on light land that had become very dry, and where we used it, we saw a significant improvement to crop health. While we didn't measure yield, we did see a significant visual improvement in the cauliflower. It was much greener and definitely less stressed. With specific clubroot pressures, Bridgeway has also proved to be effective in putting life back into struggling crops. I used Bridgeway in conjunction with fulvic acid on a field of broccoli that was heavily impacted by clubroot and together, the two products saved the crop. Before we applied it, despite it being fairly early in the crop growth stage, the field wasn't going to make a viable yield. With nothing to lose, we applied a fairly heavy dose of Bridgeway (5 L/ha) and it helped turn the crop into something that was economically viable.

James Rome, Agronomist, East of Scotland Growers

Get in touch

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Bridgeway is available to purchase through HL Hutchinsons and Frontier Agriculture Ltd