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ARTICLE

Stress in Wheat Plants Mitigated via Application of Nutrients That Could Enable Antioxidant Production

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ABSTRACT: Stress can result in up to 70% losses during crop production. Plants are exposed to abiotic stresses, such as drought or salt, or biotic stresses, such as fungal pathogens like powdery mildew or septoria. Reactive oxygen species (ROS) signalling is a part of a common response to plant stresses, but excessive ROS can be damaging. Plants produce antioxidants to reduce ROS. Wheat plants were exposed to drought stress, salt stress, and biotic stress from powdery mildew and septoria. In a glasshouse, wheat plants were treated with a functional fertiliser (Indra containing Oxygon chemistry, Levity Crop Science, UK) that could reduce the impact of stress via potential antioxidant production. For the drought, salt, and powdery mildew stresses, the functional fertiliser reduced the impact of the stresses so that the plant growth was significantly better than the plants exposed to the stresses. Under field conditions, the functional fertiliser gave control of septoria when using four fungicide applications that was comparable to seven applications without the functional fertiliser. In this work, the application of a functional fertiliser reduces the damage caused by four stresses. This gives farmers a tool to help prevent yield losses associated with plant stress.

KEYWORDS: Antioxidants; reactive oxygen species; drought stress; salt stress; powdery mildew; septoria; micronutrients

1 Introduction

Throughout their lifecycles, plants face abiotic and biotic stress; for example, abiotic stresses could be drought or salinity, while biotic stresses could be attacks by fungal pathogens or insects [1,2]. Plants that are exposed to stresses can have yield losses of up to 70% [3]. This is damaging to farmers and growers as they lose a large amount of their production that will impact them financially, and it is damaging to the environment as more land is required for agriculture, with more fertilisers and pesticides being applied to crops that will have limited yields. Wheat (*Triticum aestivum*) is an important crop in the United Kingdom, with 1.53 million ha grown in 2024 with a mean yield of 7.3 tonnes ha^{-1} [4]. Wheat yields can be reduced by exposure to stress with salt stress reducing the yield by up to 60% [5], drought stress reducing the yield by 50–60% [6], wheat powdery mildew (*Blumeria graminis* f. sp. *tritici*) stress reducing the yield by 13–34% [7], and septoria leaf blotch (*Septoria tritici*) stress reducing the yield by up to 28% [8].

There has been much research for many years looking at the impact of stresses on plant growth, and more recently, looking at two or more stresses in combination [9,10], especially related to signalling and metabolic responses. Plants can sense complex stress factors and respond to them in a suitable way, which is due to a range of signalling pathways. To be able to assess responses to different stresses in plants, it is necessary to consider where the different stress signalling pathways join, so that an integrated management solution can be identified. Rapidly forming reactive oxygen species (ROS) is a plant response to a wide range of biotic and abiotic stresses, as they are important signalling molecules [11–13]. ROS has been shown to be involved with plant responses to drought stress [14–16], to salt stress [17–19], and in disease resistance [20–25].

ROS is produced during normal metabolic processes, but it is produced in greater amounts when plants are stressed, as it is used in the stress signalling pathways. ROS can result in dangerous reactive states, like free radicals. Under normal conditions, plants have systems to reduce the damage from ROS, but when they are under stress, and more ROS is produced, these systems can be overwhelmed, and the plant is damaged [11,26]. ROS damages lipids, proteins, and DNA, which damage cells and result in cell death [17], but plants can produce antioxidant enzymes that reduce the effects of ROS [11,17,26,27]. For example, in wheat, when antioxidant enzymes and their activities were increased, there was a decrease in the oxidative damage caused by ROS [28]. Therefore, if the antioxidant defence system can be promoted, it reduces the oxidative stress; this could be an effective way to reduce damage from stress in plants [29,30].

The micronutrients zinc, manganese, iron, and copper all play roles in the synthesis of antioxidants by plants, and deficiencies can lead to an inability to increase antioxidant synthesis in response to plant signalling during periods of abiotic or biotic stress [31,32]. The use of micronutrients alongside antioxidant promoting stimulants can help plants overcome reductions in photosynthesis, stomatal conductance, and growth during exposure to or recovery from stress events. Abiotic stress is known to be a strong influence in pest and disease susceptibility, and moderating plant responses to abiotic stress may be a way to reduce the need for pesticide use [32,33].

Abiotic and biotic stresses are damaging to crop production, and farmers need a simple and reliable method to reduce the impact of stress on plants. One way of doing this would be to promote and increase the production of antioxidant enzymes in plants, as they are produced naturally to mitigate the damage caused to plants by the overproduction of ROS as a byproduct of stress. One such product is the functional fertiliser Indra that supplies boron, copper, iron, manganese, and zinc alongside the proprietary chemistry Oxygon (Levity CropScience, UK) that could reduce the impact of stress via the potential to stimulate antioxidant synthesis. Functional fertilisers contain both plant nutrients and targeted chemistry that ensures the nutrients are more readily available to plants than when the nutrients are applied without the targeted chemistry. Wheat was chosen as the test crop, as it is an important crop in many countries. Wheat was exposed to abiotic and biotic stresses to determine the impact of the micronutrient functional fertiliser on plant growth. To show that the functional fertiliser has application against a wide range of stresses, its ability to mitigate the impact of abiotic salt and drought stresses was assessed initially, before assessing its impact on the development of a biotic stress caused by wheat powdery mildew in a glasshouse, and then a final assessment was conducted as part of a field trial in a commercial crop and its ability to influence the control of septoria leaf blotch.

2 Materials and Methods

2.1 Salinity Abiotic Stress

Wheat seeds (RGT Saki, RAGT Seeds Ltd, Essex, UK, and LG Astronomer, Limagrain UK, Lincolnshire, UK) were sown in plug trays filled with Sinclair's reduced peat compost and transplanted to 0.6 L pots containing the same compost at the two-leaf stage. At transplant, irrigation started with either water or a 30 mM NaCl solution, which continued for six weeks, at which time the plants were harvested. The saline irrigation solution was replaced twice a week to maintain the salt concentration. The 30 mM NaCl can be converted to an electrical conductivity (EC) value of 3.3 dS/m, which is high as water with an EC of over

3 dS/m can pose a serious issue to crop production when it is used for irrigation. Within each irrigation treatment, plants were either treated with one 0.5% functional fertiliser (containing B 0.025%, Cu 2%, Fe 1.5%, Mn 0.5% and Zn 2%) application (comparable to 1 L Ha^{-1}) or water, applied at transplant. For each of the four treatments, 10 plants were grown. Weekly, the plants had their height, number of leaves, and number of tillers recorded, with the wet weight of the above-ground parts of the plant recorded on the final scoring date. The plants were grown in a glasshouse located in Lancashire, UK (temperature min. 14°C, max. 19°C, relative humidity max. 85%, min. 13 h light over 15 klux). The experiment was run three times using RGT Saki seeds and two times using LG Astronomer seeds.

2.2 Drought Abiotic Stress

Wheat seeds (LG Astronomer) were sown in plug trays filled with Sinclair's reduced peat compost and transplanted to 0.6 L pots containing the same compost at the two-leaf stage. At transplant, irrigation started by placing pots in trays containing either water or a 1.5 or 4.5% PEG 6000 (polyethylene glycol 6000) (Melford Laboratories Ltd., Chelsworth, UK) solution, which continued for four weeks, at which time the plants were harvested. The 1.5% PEG 6000 solution gave a specific osmotic potential of 0.014 MPa, and the 4.5% PEG 6000 solution was 0.056 MPa. Within each irrigation treatment, plants were ether treated with two 0.5% functional fertiliser applications (comparable to 1 L Ha^{-1} per application) or water, applied at transplant and two weeks later. For each of the six treatments, 10 plants were grown. Weekly, the plants had their height, number of leaves, number of tillers, and growth stage recorded. The plants were grown in a glasshouse located in Lancashire, UK (temperature min. 14°C max. 19°C, relative humidity max. 85%, min. 13 h light over 15 klux). The experiment was run twice.

2.3 Powdery Mildew Biotic Stress

Winter wheat seeds (RGT Saki) were sown in 1.6 L pots filled with Sinclair's reduced peat compost. There were two seeds per pot, with the second seed to germinate removed to leave only one plant per pot. Plants were watered as required to keep the compost moist. The experiment consisted of two treatments (untreated control/water and functional fertiliser) with 15 plants per treatment. The functional fertiliser was applied as a 1% solution every three weeks throughout the experiment. Established wheat plants (grown in the same way) with visible and sporulating wheat powdery mildew (*B. graminis* f. sp. *tritici*) were present in the same glasshouse, and spores from these plants were used to inoculate the newly germinating seedlings. Weekly, the percentage of the leaf area of the whole plant covered by powdery mildew was estimated. No other fertilisers or fungicides were applied during the experiment. The plants were grown in a glasshouse located in Lancashire, UK (temperature min. 14°C max. 19°C, relative humidity max. 85%, min. 13 h light over 15 klux). The experiment was repeated twice.

2.4 Septoria Biotic Stress

A field trial in the UK was conducted by Oxford Agricultural Trials (OAT) using winter wheat (RGT Gravity) with four plots each of 12 × 2.5 m for untreated (no fungicide applications), farm standard (seven fungicide applications following the farm's standard procedure), and reduced fungicide applications (four fungicide applications and four functional fertiliser applications) in a randomised block design. The whole site was managed by OAT, who applied standard herbicide, plant growth regulator, and insecticide programmes, with the only differences between the plots being the application of fungicides. Fungicides were applied at four timings: 1. BBCH growth stage (GS) 30, 2. GS 32, 3. GS 39, and 4. GS 59. The farm standard fungicide programme was Folicur and Arizona at application timing 1, Aviator Xpro and Arizona at application timing 2, Revystar XE and Arizona at application timing 3, and Folicur at application timing 4. The reduced fungicide application programme was Folicur and functional fertiliser at application timing 1, Aviator Xpro and functional fertiliser at application timing 2, Revystar XE and functional fertiliser at application timing 3, and Folicur and functional fertiliser at application timing 4. All fungicides and the functional fertiliser were applied following the manufacturer's instructions using a compressed air backpack sprayer. The septoria leaf blotch (*S. tritici*) was scored at GS 71 as percent leaf coverage. At harvest, the specific weight and yield were recorded, with the yield being reported as a percentage increase over untreated.

2.5 Statistical Analysis

The Jamovi 2.3.28 for Windows software [34] was used for statistical analysis, with $p < 0.05$ used to show significance. Normality of data was determined using the Shapiro-Wilk test, and the homogeneity was determined using Levene's test. Data from the salinity trial for the number of tillers was normally distributed and was analysed by a one-way ANOVA followed by a Games-Howell post-hoc test. Data from the salinity trial for the number of leaves and shoot weight, and for the drought trial for the number of leaves and number of tillers were not normally distributed and were analysed by a one-way ANOVA (non-parametric) followed by a Dwass-Steel-Critchlow-Fligner pairwise comparison. Data from the powdery mildew trial were not normally distributed and were analysed with a Mann-Whitney U test. Data from the septoria trial were normally distributed and were analysed with an ANOVA followed by the Student-Newman-Keuls test.

3 Results

3.1 Salinity Abiotic Stress

All five repeats of the experiment gave very similar results. All the data from the five separate repeats were combined, and the statistical analysis was run again for the combined data to give a larger data set, but the experimental repeat was not included as a factor in the analysis, as each repeat was run under conditions that would not be expected to impact the growth of the plants, and to keep the analysis simple and focused.

There were no significant differences in the height of the wheat plants between the five treatments. For the number of leaves and number of tillers, the plants exposed to salt stress had significantly fewer leaves or tillers than the untreated plants not exposed to stress, and the functional fertiliser application mitigated the effect of the salt as the number of leaves or tillers in the plants exposed to salt and treated with the functional fertiliser were the same as for the untreated plants and significantly more than for the plants exposed to just salt ($p < 0.05$, Figs. 1 and 2). For the harvested shoot weight (harvested at growth stage 24–26), six weeks after transplanting to pots and starting the saline irrigation and functional fertiliser application, the salt treated plants had significantly less mass than the untreated plants not exposed to saline water, while the functional fertiliser application to the saline irrigated plants increased the harvested weight so that it was no longer significantly worse than the untreated plants ($p < 0.05$, Fig. 3). For all parameters scored, when the functional fertiliser was applied without saline irrigation water, the plants were not significantly different from the untreated plants.

3.2 Drought Abiotic Stress

Both repeats of the experiment gave very similar results and the data from the separate repeats were combined and the statistical analysis was run again for the combined data to give a larger data set, but experimental repeat was not included as a factor in the analysis as each repeat was run under conditions that would not be expected to impact the growth of the plants and to keep the analysis simple and focused.

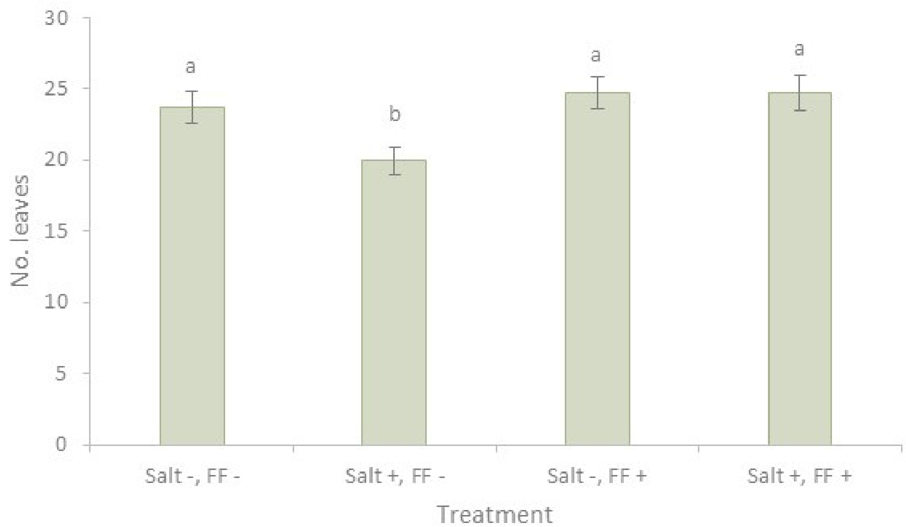

Figure 1: Number of leaves for wheat plants irrigated with water (Salt−) or 30 mM NaCl (Salt+) for six weeks from two leaf stage and treated with 0.5% functional fertilizer once at two leaf stage (ff+) or untreated (ff−). Lowercase letters indicating significant differences between treatments (n = 50, bars represent standard error, $p < 0.05$, one-way ANOVA (non-parametric) followed by a Dwass-Steel-Critchlow-Fligner pairwise comparison).

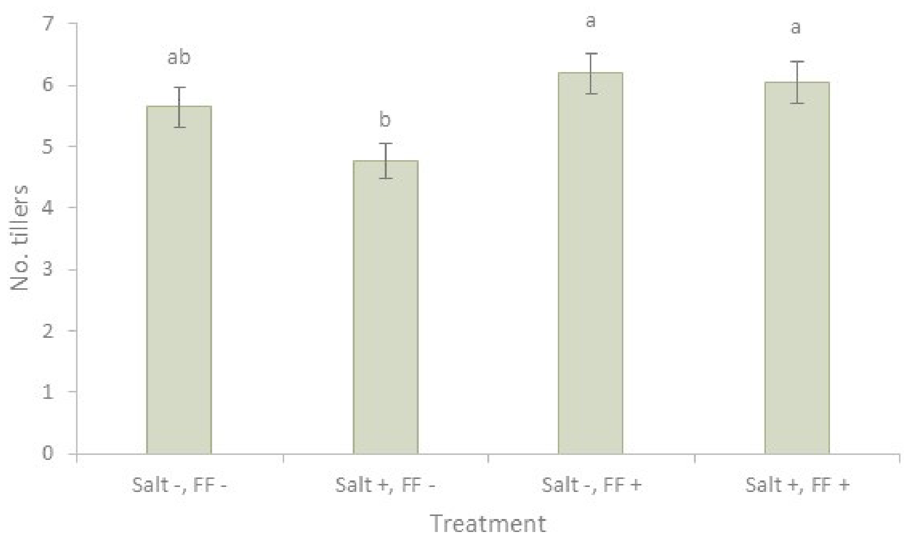

Figure 2: Number of tillers for wheat plants irrigated with water (Salt−) or 30 mM NaCl (Salt+) for six weeks from two leaf stage and treated with 0.5% functional fertilizer once at two leaf stage (ff+) or untreated (ff−). Lowercase letters indicating significant differences between treatments (n = 50, bars represent standard error, $p < 0.05$, one-way ANOVA followed by a Games-Howell post-hoc test).

Both drought treatments (1.5 and 4.5% PEG 6000) resulted in significant reductions in the number of leaves compared to the 0% PEG 6000 treatment ($p < 0.05$, Fig. 4). There were significant increases in the number of leaves when the functional fertiliser was applied for both drought treatments ($p < 0.05$, Fig. 4). For the number of tillers both drought treatments caused significant reductions compared to the 0% PEG

6000 treatment ($p < 0.05$, Fig. 5). When the functional fertiliser was applied to the 1.5% PEG 6000 treated plants it resulted in a significant increase in the number of tillers, but there was no increase in the number of tillers for the 4.5% PEG 6000 treated plants ($p < 0.05$, Fig. 5).

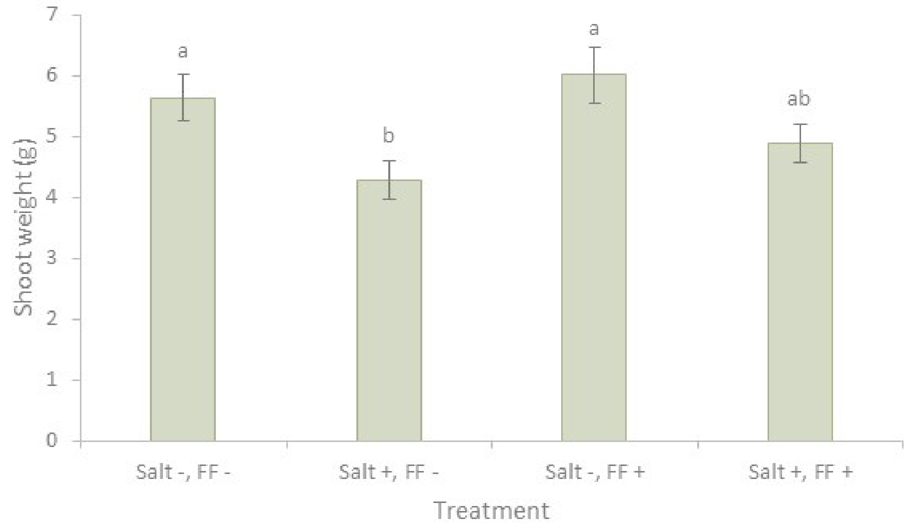

Figure 3: Shoot weight (g) for wheat plants irrigated with water (Salt−) or 30 mM NaCl (Salt+) for six weeks from two leaf stage and treated with 0.5% functional fertilizer once at two leaf stage (ff+) or untreated (ff−). Plants were harvested at growth stage 24–26. Lowercase letters indicating significant differences between treatments (n = 50, bars represent standard error, $p < 0.05$, one-way ANOVA (non-parametric) followed by a Dwass-Steel-Critchlow-Fligner pairwise comparison).

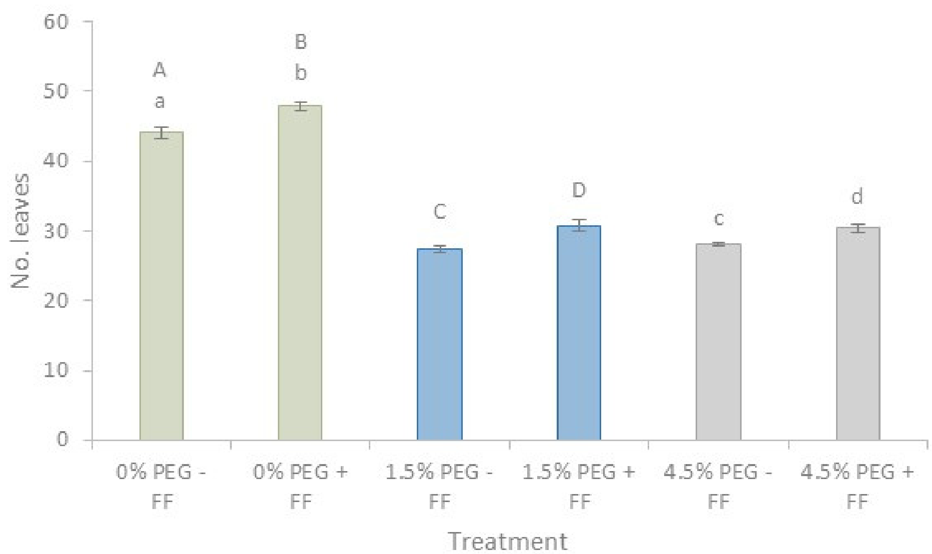

Figure 4: Number of leaves for wheat plants grown in water (0% PEG) or 1.5 or 4.5% PEG for four weeks from two leaf stage and treated twice with 0.5% functional fertilizer at two leaf stage and two weeks later (+ff) or untreated (−ff). Significant differences between the water and 1.5% PEG are shown by capital letters while significant differences between the water and 4.5% PEG are shown by lowercase letters (n = 20, bars represent standard error, $p < 0.05$, one-way ANOVA (non-parametric) followed by a Dwass-Steel-Critchlow-Fligner pairwise comparison).

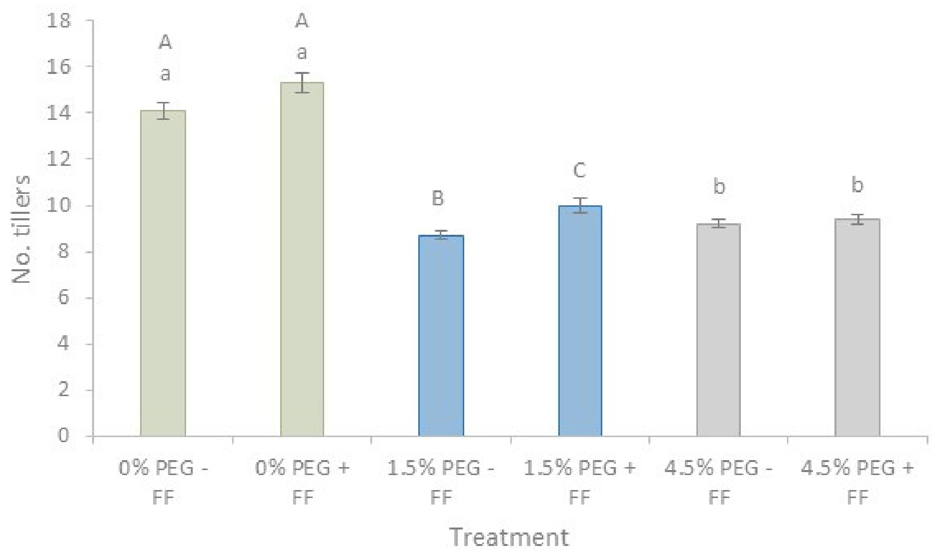

Figure 5: Number of tillers for wheat plants grown in water (0% PEG) or 1.5 or 4.5% PEG for four weeks from two leaf stage and treated twice with 0.5% functional fertilizer at two leaf stage and two weeks later (+ff) or untreated (−ff). Significant differences between the water and 1.5% PEG are shown by capital letters while significant differences between the water and 4.5% PEG are shown by lowercase letters (n = 20, bars represent standard error, $p < 0.05$, one-way ANOVA (non-parametric) followed by a Dwass-Steel-Critchlow-Fligner pairwise comparison).

3.3 Powdery Mildew Biotic Stress

The results from both repeats of the experiment were similar and the data from the separate repeats were combined and the statistical analysis was run again for the combined data to give a larger data set, but experimental repeat was not included as a factor in the analysis as each repeat was run under conditions that would not be expected to impact the growth of the plants and to keep the analysis simple and focused.

From seven to 35 days after treatment the levels of PM were similar on the treated and untreated plants. Then from 42 to 56 days after treatment the PM on the untreated plants increased with the level on the functional fertiliser treated plants increasing at a much lower rate with significant differences between the two treatments. On the final scoring date 63 days after treatment, the PM on the functional fertiliser treated plants increased, but was still significantly less than on the untreated plants ($p < 0.05$, Fig. 6). The area under disease progress curve (AUDPC) for the powdery mildew on the untreated plants was significantly greater than for the functional fertiliser treated plants ($p < 0.05$, Fig. 7). The functional fertiliser applications were able to slow the development of the PM epidemic on the treated plants.

3.4 Septoria Biotic Stress

For the percentage of the leaf area of leaves 1, 2, and 3 infected with septoria, the results were similar, with the untreated plants having a significantly greater leaf area covered by septoria than for the plants treated with the standard farm fungicide programme or the reduced fungicide program where the number of fungicide applications was reduced while applications of a functional fertiliser were also applied, with no significant differences between the two treatments ($p < 0.05$, Fig. 8).

When measuring the yield, for the specific weight, the reduced fungicide application program with functional fertiliser gave a significant increase over the untreated plants, with the standard fungicide program not showing any significant differences from either of the other treatments ($p < 0.05$, Fig. 9). For the percentage increase over the untreated yield, both fungicide treatments gave increases compared to the untreated yield, with no significant differences between the two treatments ($p < 0.05$, Fig. 9).

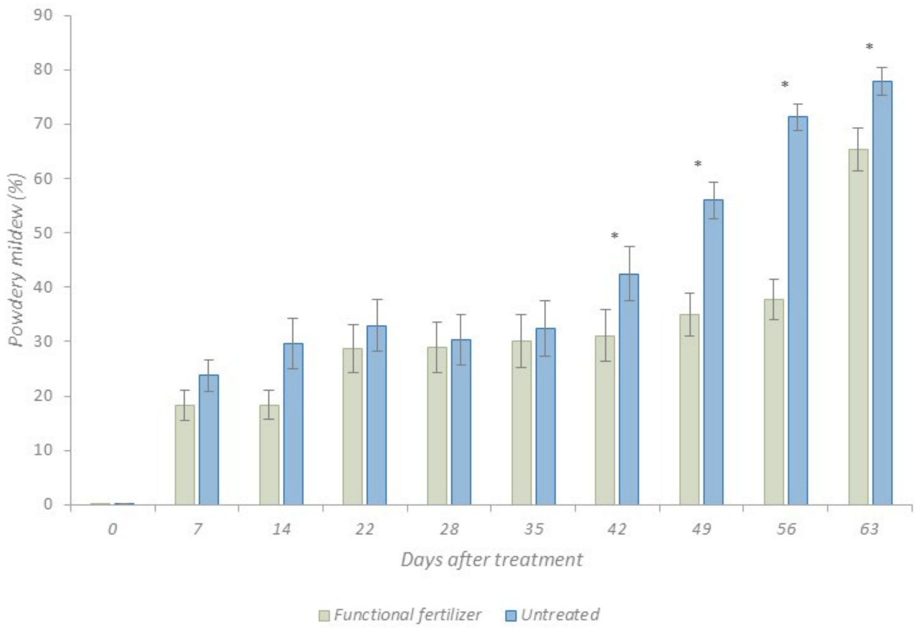

Figure 6: Percentage of powdery mildew infection on leaves of winter wheat plants grown in a glasshouse scored weekly following applications of 1% functional fertilizer every three weeks. Significant differences between functional fertilizer and untreated for each scoring date are indicated by * above the bars (n = 30, bars represent standard error, $p < 0.05$, Mann-Whitney U test).

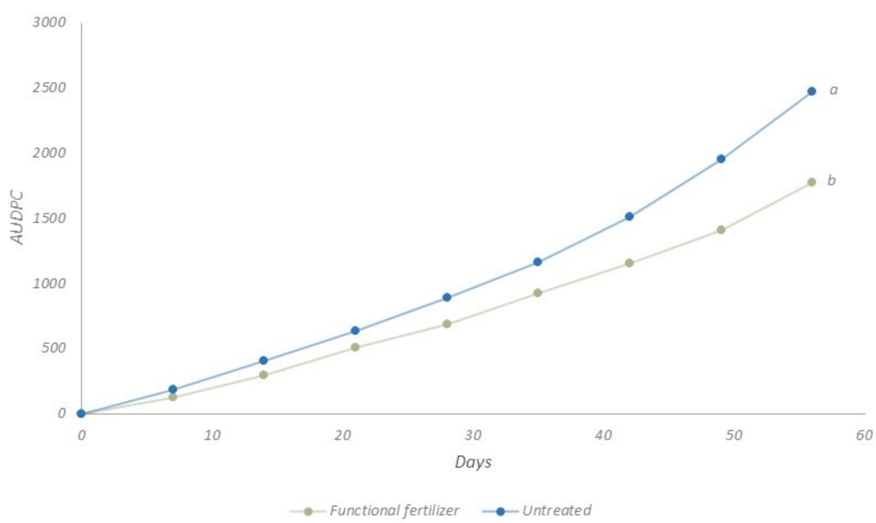

Figure 7: Area Under Disease Progress Curve (AUDPC) of powdery mildew infection on leaves of winter wheat plants grown in a glasshouse scored weekly following applications of 1% functional fertilizer every three weeks. Significant differences between functional fertilizer and untreated are indicated by lower case letters (n = 30, $p < 0.05$, Mann-Whitney U test).

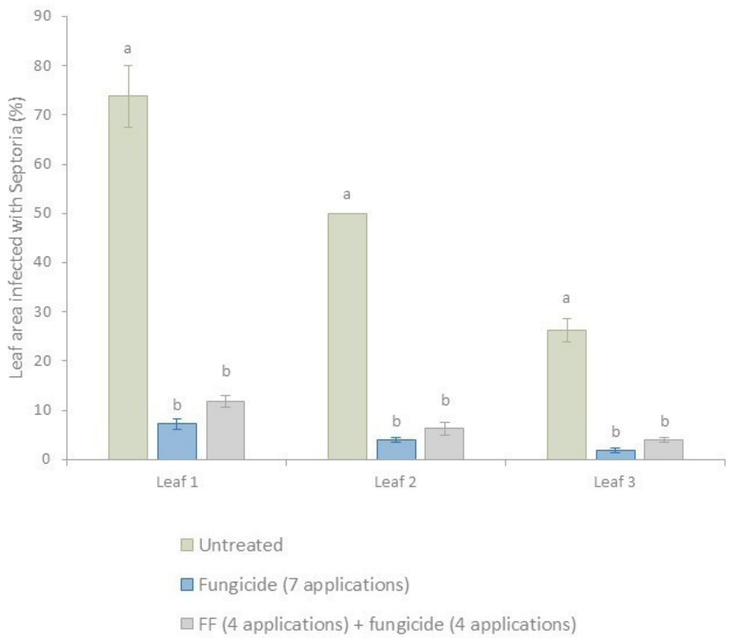

Figure 8: Percentage of septoria infection at GS 71 on leaves of field grown winter wheat plants following no fungicide applications (untreated), farm standard fungicide applications (fungicide (7 applications)), and reduced fungicide applications (functional fertilizer (FF) (4 applications) + fungicide (4 applications)). Lowercase letters indicate significant differences between treatments for each leaf (n = 4, bars represent standard error, $p < 0.05$, ANOVA followed by Student-Newman-Keuls test).

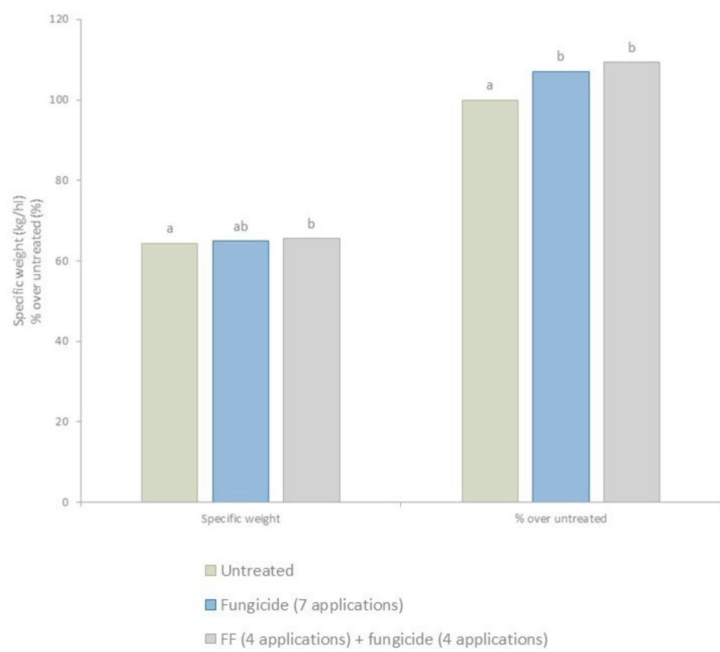

Figure 9: Specific weight and yield as % over untreated at harvest for field grown winter wheat plants following no fungicide applications (untreated), farm standard fungicide applications (fungicide (7 applications)), and reduced fungicide applications (functional fertilizer (FF) (4 applications) + fungicide (4 applications)) for septoria. Lowercase letters indicate significant differences between treatments for specific weight or % over untreated (n = 4, bars represent standard error, $p < 0.05$, ANOVA followed by Student-Newman-Keuls test).

4 Discussion

Plant stress has a significant impact on crop growth and yield, with losses of up to 70% reported [3]. There is a wide range of abiotic and biotic stresses that can affect plants both individually and in combination [1,2]. Previous work has shown that ROS is part of an important signalling pathway for many, if not all, stresses in plants [11–13], and that the overproduction of ROS under high stress environments can be very damaging to plants [11,17,26]. Plants produce antioxidants to manage and reduce the ROS that they produce [26,27], and the antioxidants can reduce the damage caused to the plants [29,30].

As crops will face several stresses between germination and harvest, this work aimed to show that a functional fertiliser that could increase the potential for antioxidant production could mitigate the impacts of four stresses. Wheat was used in this work as it is an important cereal crop and grown globally. Drought and salt stresses are two common abiotic stresses, and ROS is involved in plant responses to these stresses in wheat for drought [15,16] and salinity [18,19].

This work considered the functional fertiliser as a complete product, as it would be formulated when used as a commercial product, but the functional fertiliser is composed of 1. the micronutrients boron, copper, iron, manganese, and zinc, and 2. the proprietary chemistry Oxygon, but these two parts of the functional fertiliser were not assessed separately in this work. Therefore, the effects of the applications of the functional fertiliser cannot be determined to be due to enhanced nutrition or another mechanism.

In this work, when wheat seedlings were exposed to salinity stress and treated with a functional fertiliser that has been formulated to potentially mitigate stress and has the potential to promote antioxidant production, the fertiliser treatment maintained the growth of the seedlings at the same level as the seedlings not exposed to the salt stress (Figs. 1–3). Previous work has suggested the use of arbuscular mycorrhizal fungi as a method to remove the excess ROS and increase productivity in wheat, but the salt stress decreased the root colonisation by the arbuscular mycorrhizal fungi for one wheat cultivar, while in the other cultivar, the arbuscular mycorrhizal fungi enhanced the plant productivity [18]. Arbuscular mycorrhizal fungi could be a method to mitigate the effects of salt stress in wheat, but correct strains must be identified, inoculated into the seed bed to colonise the roots, and then not be affected by the salt stress they are being used to mitigate. This work showed similar beneficial effects from a foliar application of a functional fertiliser, which could be more easily applied. Alternatively, breeding tolerant cultivars has been suggested [19], but this is a long and time-consuming process that will not benefit wheat crops planted now. Nutrient management is an important method for mitigating salt stress that can be applied to any wheat crop [19], which is the method used in this work, as a functional fertiliser has been used to maintain the growth of wheat seedlings under salt stress in a glasshouse experiment, so there is a need for further study under field conditions.

Drought stress is another important abiotic stress that wheat and other crops are widely exposed to. This work used two rates of polyethylene glycol 6000 to simulate drought stress in wheat seedlings grown in a glasshouse for four weeks. For both rates, when a functional fertiliser that has the potential to promote antioxidant production was applied, the wheat seedlings grew significantly better than when the fertiliser was not applied (Figs. 4 and 5). A functional fertiliser is convenient to use and easy to apply, which contrasts with other suggested methods to mitigate the effects of drought stress on wheat plants, such as seed priming, cultivar selection, or breeding new varieties [16]. When comparing less drought tolerant rice plants with wheat plants, it was found that regulating photosynthesis, as well as protection against the oxidative bust of ROS production, were what gave wheat the better drought tolerance over rice [15]. The use of the functional fertiliser in this work has the potential to promote antioxidant production, which could potentially further enhance wheat's drought tolerance through better oxidative protection.

ROS has been shown to be involved in the responses of wheat to biotic stress caused by powdery mildew [22,23] and septoria [25]. In this work, wheat seedlings were exposed to wheat powdery mildew inoculum, and the disease levels were allowed to develop over time. In plants treated with a functional fertiliser, the amount of powdery mildew infection present was significantly reduced compared to untreated plants (Figs. 6 and 7). Previous work has shown that when wheat plants were inoculated with powdery mildew, the ROS that was produced in response to the biotic stress was linked to cell death [22]. Antioxidants are produced to prevent damage to plants by ROS [11,26], but in the previous study, when wheat plants were inoculated with powdery mildew, the antioxidants could not cope, and damage was still observed. This could be because mild powdery mildew infection has been shown to induce antioxidant systems in wheat attacked by powdery mildew, but when the powdery mildew was at a higher level, the antioxidant systems were inhibited [23]. The functional fertiliser used in this work that has the potential to promote antioxidant production could potentially help the plant overcome the damage caused by the ROS produced due to infection with powdery mildew, as if the level is too high, the plant could stop producing antioxidants naturally, but the precise mechanism by which this happens has not been determined yet.

Under field conditions, farmers will use a range of methods to combat biotic stress, which will include pesticides, such as fungicides, to combat fungal infections. If the infected plants are better able to defend themselves from an attack due to having better nutrition, then fewer fungicides will need to be applied. Septoria is a globally important fungal disease of wheat [35], where the disease has a long symptomless latent phase before a shorter and suddenly occurring necrotrophic phase [36]. In this work, in an independently managed field trial, the number of fungicide applications needed to control septoria was reduced from seven to four when a functional fertiliser was applied at the same time, and the level of control or yield obtained was not reduced (Figs. 8 and 9), but these results were from a single site and single season, so further work will be needed to confirm them and ensure that broad agronomic conclusions about fungicide reductions can be fully supported. During the symptomless growth of septoria, there are only minor metabolic responses, but when it switches to the necrotrophic growth phase, there are responses including oxidative stress [36]. The addition of the functional fertiliser to the reduced fungicide program could potentially prevent the additional damage from the oxidative stress that is present in addition to the necrotic damage caused by the septoria.

5 Conclusions

ROS is involved in plant responses to a wide range of stresses, and that excessive amounts of ROS is produced when a plant is stressed, which can be damaging to the plant. It has been shown that a functional fertiliser that could potentially reduce the impact of stress via the potential promotion of antioxidant production can reduce the impact of four plant stresses in wheat, but the precise mechanism by which this happens has not been determined yet. In this work, the functional fertiliser has been used with wheat, a globally important cereal crop, to show that its application can prevent the negative effects of the abiotic salt and drought stresses and the biotic stresses caused by the fungal pathogens powdery mildew and septoria. When assessing the impact of the functional fertiliser on salt, drought, and powdery mildew stresses, the work was conducted in a glasshouse, so further assessment will be needed under field conditions to confirm that the same responses are seen there. This functional fertiliser can help reduce the impacts of four stresses in wheat.

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Author Contributions: The authors confirm contribution to the paper as follows: Conceptualization, Jolyon Dodgson, Anna K. Marks and David J. Marks; methodology, Jolyon Dodgson, Anna K. Marks and David J. Marks; formal analysis, Jolyon Dodgson; investigation, Jolyon Dodgson; resources, Anna K. Marks and David J. Marks; writing—original draft preparation, Jolyon Dodgson; writing—review and editing, Jolyon Dodgson, Anna K. Marks and David J. Marks. All authors reviewed and approved the final version of the manuscript.

Availability of Data and Materials: The data that support the findings of this study are available from the Corresponding Author, Jolyon Dodgson, upon reasonable request.

Ethics Approval: Not applicable.

Conflicts of Interest: The authors are employees of a company that may be affected by the presented research. The mentioning of specific commercial products is only for providing information and does not provide a recommendation. Other similar products could be used to conduct similar research.

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