FINAL REPORT

The Agronomy of Glyphosate and Radiate in Glyphosate resistant crops.

Author: Thomas McGuire

Title: Manager - Technical Services, LPI. CO.

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Abstract Summary

Glyphosate resistant crops are tolerant of glyphosate but they are not immune to its herbicidal effects or to the effects of the glyphosate metabolite AMPA, which is a known phytotoxin. Glyphosate and AMPA have been shown to affect important physiological functions essential for plant growth and development. It is believed that applications of glyphosate in (Glyphosate Resistant) GR crops can interfere with the production of amino acids phenylalanine, tyrosine and tryptophan. It is thought that tryptophan is a precursor for Indole-3-acetic acid (IAA) biosynthesis in plants. IAA is the most abundant auxin in plants and is one of the most important auxins involved in plant growth and development. Exogenous applications of Indole-3-butyric acid (IBA) applied in conjunction with glyphosate to GR crops are converted to IAA in the plant. IBA in the form of Radiate® in laboratory testing demonstrated when applied in conjunction with glyphosate, it can assist GR crops to recover faster from negative physiological effects and phytotoxicity glyphosate can induce in GR crops.

Introduction

The broad spectrum non selective herbicide glyphosate is the most commonly used herbicide by farmers worldwide (Duke *et al.,* 2008). Since its introduction to agriculture this herbicide has made fallow weed control and the cultural practices of zero/minimum tillage farming a reality. The advent of glyphosate resistant (GR) crops more recently has made it also a popular tool for in crop post emergent weed control (Duke *et al.,* 2008).

While not completely understood, the general consensus on how glyphosate works in plants according to (Siehl, 1997) and (Gomes *et al.,* 2014) is "through inhibition of the 5-enolpyuvylshikimate-3-phosaphate synthase (EPSPS), an enzyme from the shikimate pathway, which leads to prevention of biosynthesis of the amino acids phenylalanine, tyrosine and tryptophan." Bartel (1997) and Zhao (2010) have stated that isotope testing has provided evidence to suggest that "tryptophan is a precursor for Indole-3-acetic acid (IAA) biosynthesis in plants". The role of IAA in plants will be discussed later in more detail.

Glyphosate is a systemic herbicide that is taken up by plants and translocated through vascular tissues to actively growing parts of the plant which are high in metabolic activity such as roots and shoots (Satchivi *et al.,* 2000). It has been reported (Zobiole *et al*., 2009, 2010c, 2012) and shown (Kremer *et al.,* 2009; Kielak *et al.*, 2011) that glyphosate affects plant physiological functions including "photosynthesis, carbon metabolism, mineral nutrition and oxidative events and to disturb plant microorganism interactions" (Gomes *et al.,* 2014). GR crops are resistant to sub lethal doses of glyphosate, however, they are not immune to the herbicidal effects of glyphosate (Reddy *et al.,* 2004) or to phytotoxicity. Phytotoxicity can occur in GR crops after post emergent glyphosate applications have been made due to unfavourable environmental conditions prevailing which hinder crop growth. Symptoms of phytotoxicty in GR crops include chlorosis, brown necrosis and growth inhibition which can lead to yield reduction.

Amino-methylphosphonic acid (AMPA) has been identified as a primary glyphosate metabolite and it occurs when glyphosate is degraded by micro-organisms in soils (Franz *et al*., 1997; Van Eerd *et al.,* 2003 & Gomes *et al.,* 2014). Reddy *et al*., (2004) believes that a similar method of glyphosate degradation occurs in plants and the presence of glyphosate and AMPA in plant tissue is evidence of this. AMPA can be taken up by the plant through soil and water plant interactions as can glyphosate (Reddy *et al.,* 2004). AMPA is a known phytotoxin and AMPA phytotoxic symptoms have been observed in GR crops (Reddy *et al.,* 2004). AMPA can be transported within the plant to a number of important plant organs and tissues; therefore these sites become sinks in the plant for glyphosate and AMPA (Feng *et al.*, 2003; Gomes *et al.,* 2014; Hetherington *et al.*, 1999; & Reddy *et al*., 2004). According to Zobiole *et al.,* (2011b) "even when plants don't come into contact with AMPA or they don't possess glyphosate oxidoreductase (the enzyme responsible for degrading glyphosate into AMPA) glyphosate can cause a decrease in chlorophyll content by depriving Nitrogen biosynthesis."

The presence of glyphosate and AMPA in sinks of GR crops is thought to cause changes in plant physiological functions which may also contribute to the herbicidal effect of glyphosate (Gomes *et al.,* 2014) albeit this is lower for GR crops compared to glyphosate sensitive (GS) plants. Reddy *et al.,* (2004) believes that "glyphosate induced injuries in GR crops are due to AMPA formed from glyphosate degradation". AMPA is chemically alike to glycine and in plants AMPA can displace glycine causing it to affect chlorophyll production of complex molecules, impacting photosynthetic activity rates and reducing plant growth (Gomes *et al.,* 2014). Reddy *et al.,* (2004) also reported that it is the rate of degradation of glyphosate to AMPA and "not glyphosate" itself which is responsible for this impact on chlorophyll biosynthesis (Gomes *et al.,* 2014).

Scientific evidence exists today that supports the theory that Indole-3-acetic acid (IAA) levels in the plant are tied to glyphosate plant injury (Westwood *et al,* 1985). IAA is the primary auxin produced in higher plants; it's the most abundant auxin and it is involved in nearly all facets of plant growth and development (Zhao, 2010). Taiz *et al.*, (1998) stated that, IAA is involved in many important physiological processes in plants, playing a key role in cell enlargement/division, tissue differentiation and plant feedback to light as well as gravity. In the late 1970's and early to mid1980's Baur (1979) determined that glyphosate effects and reduces IAA transport in corn and cotton tissue.

In order to see the effect glyphosate can have on plant physiology, glyphosate was applied at sub lethal rates to monocotyledon and dicotyledonous plants. In Bermuda grass it stimulated branching to occur (Fernandez *et al.,* 1977) and in soybeans/peas seedlings it caused these plants to produce lateral buds even though apical dominance was being expressed (Lee, 1984). These results provide evidence to support the theory that sub-lethal doses of glyphosate in non GR crops reduces IAA levels in these plants. The plant growth peculiarities observed in these trials are normally regulated through the process of correlative inhibition (Westwood *et al.*, 1985). It occurs when plant growth is suppressed by a compound produced in another area of the plant. IAA is thought to be an important component of correlative inhibition and it assists to inhibit unwanted lateral branching (Westwood *et al.,* 1985).

Scientific studies have proven that exogenous applications of IAA or synthetic auxins to plants can provide positive benefits relating to plant physiology (Zhao, 2010). Lee, (1980b) confirmed that IAA reversed glyphosate induced inhibition in tissue cultures of soybeans and tobacco (Westwood *et al,* 1985). According to Lee (1982a, b) when exogenous IAA is applied to callus cultures treated with glyphosate; IAA and IAA oxidase levels don't appear to be effected by glyphosate but there is a reduction in the amount of free IAA and IAA oxidation products in these cultured tissues; bound IAA levels and products of IAA oxidation increased though (Westwood *et al.,* 1985). Lee (1980a, 1982b) has also speculated "that a reduction of IAA levels in plants treated with glyphosate may be caused by an observed decrease in phenolic compounds known to influence IAA oxidase activity".

Exogenous IAA can be applied to crops via foliar applications of the synthetic auxin Indole-3-butyric acid (IBA). Applications of IBA are converted to IAA in plants (Nordstrőm *et al.,* 1991). Ludwig-Müller (2000) suggested there is some evidence that "IBA may act as an auxin on its own, not via its conversion to IAA." To date, no scientific data has been generated to definitively prove synthetic auxins can replace auxins in plant cells; however, it has been proven that synthetic auxins can add to the auxin pool (Bartel *et al*., 2001). IBA is the most popular plant growth hormone utilized in commercial agriculture and horticulture today due to it being more stable than IAA (Davis *et al.*, 1988). IBA also out performs IAA when it comes to promoting fortuitous root systems (Epstein & Ludwig-Muller, 1993).

Radiate® is a synthetic plant growth hormone invented by CH Bio, distributed by Loveland Products and sold through Crop Production Services (CPS). Radiate® contains IBA (Auxin) and Kinetin (cytokinin) in an optimised ratio to maximize desired outcomes in treated crops (CH Bio). Kinetin has been classified as a cytokinin, which are plant growth hormones that occur naturally in plants and some can also be produced synthetically. Kinetin is synthesized in plant roots, developing embryos, young leaves and in fruits (Osugi *et al*., 2015). The benefits of applying additional kinetin to crops via exogenous applications include - stimulation of cell division (Cytokinesis), promotion of shoot growth, promotion of lateral bud growth, improved nutrient mobilization, stimulation of reproductive development and delaying leaf senescence (CH Bio).

It has been proven in fully randomised and replicated field trial work with supporting data from large scale grower commercial demonstration trials that Radiate® performs the following functions in crops it is applied to:

- Promotes root and shoot growth,
- Improves early season vigour,
- Enhances the crop's ability to produce more natural growth hormones,
- Reduces early season stress,
- Increases overall plant health to optimise desired outcomes in crops, i.e. yield and quality. (CH Bio & LPI).

As there is evidence now available to support the theory that glyphosate applications to GR crops can have detrimental impacts on essential plant physiological functions and reduce IAA levels in these crops (Reddy *et al.,* 2004) and Lee (1980b), confirmed that IAA reversed glyphosate induced inhibition in tissue cultures of soybeans and tobacco (Westwood *et al.,* 1985), it stands to reason that exogenous applications of Radiate® applied in conjunction with glyphosate herbicide should be beneficial in assisting GR crops to recover from post emergent glyphosate applications and environmental conditions which can induce herbicide phytotoxicity. It was time to test this in the lab. (CH Bio & LPI). In 2016 CH Bio, Taiwan, conducted the following experiment to see if data could be generated in their laboratory to substantiate and support the use of Radiate® combined with post emergent glyphosate in GR crops.

Aims

- To determine if the plant growth hormone Radiate® when applied in conjunction with glyphosate can have positive influences on important plant physiological processes affected by glyphosate in GR canola and soybeans.

- To determine if Radiate® when applied in conjunction with glyphosate on GR resistant canola and soybeans showing symptoms of phototoxicity, can assist these crops to recover sooner from this damage.

Objectives

1. Grow GR canola and GR soybean seedlings in a lab growth chamber to produce plants that are going to have soft tissue and will be susceptible to glyphosate induced herbicide phytotoxicity.

2. Assumptions:

    - Plants from the growth chamber (that have not been exposed to normal environmental conditions commercial crops experience) are more likely to show phytotoxic symptoms which can be observed when glyphosate applications are made to young GR crops, that are not actively growing or are under plant stress.

    - The rate of glyphosate applied in a laboratory environment to GR plants will be more concentrated than it will be in a commercial application scenario due to the ability to improve spray accuracy and coverage in the lab. This may also assist to induce phytotoxicity.

    - The addition of Radiate® (IBA > IAA) to glyphosate applications on GR crops may reduce the impact glyphosate has on essential plant physiological functions which are crucial for crop development, growth and yield.

3. Apply glyphosate applications to GR canola and GR soybeans with and without Radiate®. Compare these treated plants to the untreated control.

4. Measurements:

    - Take photographs of untreated and treated plants @ 3 DAT & 6 DAT.
    - Plant Biomass (Shoot & Root - fresh & dry weights),
    - Chlorophyll content,
    - Photosynthesis Rate,
    - Electrical Conductivity(EC) of leaf cells,
    - Reactive Oxygen Species (ROS).

5. Perform relevant calculations to determine the results from testing procedures.

6. Interpretation of results.

7. Generate conclusions and formulate recommendations from trial work.

Materials and Methods

Plant material:

Crop/Seeds	Variety	Developed By	Growth Stage
Canola (Brassica Napus) Spring Hybrid	PV 533 G	Genuity Roundup Ready	Cotyledon and first true leaf
Soybean	P32T25R2	Pioneer Roundup Ready II	V1

Treatments:

	Products	Rate
T1	Untreated control – 80% Non-ionic surfactant	0.1%
T2	540g/L Fully Loaded Glyphosate + 80% Non-ionic surfactant	0.75lb ae/Acre + 0.1%
T3	540g/L Fully Loaded Glyphosate + Radiate® + 80% Non-ionic surfactant	0.75lb ae/Acre + 1000 x Radiate + 0.1%

Application:

Method - Foliar sprayed.

Photographs:

Method - At 3 and 6 days after treatment (DAT) take photographs of the treated and untreated GR canola and GR soybeans plants to show differences between the individual treatments in the trial and to provide evidence that phytotoxic symptoms were able to be induced.

Biomass assessment (Roots & Shoots):

Method - Using a portion of the treated and untreated plants in the trial, perform crop destruct measurements by removing GR canola and soybean plants from pots and washing root systems free from growing media.

Remove roots from plant tops and weigh roots for each treatment and record values. Perform the same procedure on the shoots removed from the tops of the seedlings.

Dry collected plant material for each treatment in an oven for 24 hours at 60° Celsius, weigh dried roots and shoots for each treatment and record values.

Chlorophyll content:

Method - Weigh a pre-determined amount of fresh leaf tissue, grind it into a powder, add acetone and wait until the color changed from green to white. Measure the absorbance of the supernatant at 645 and 663 nm by spectrometer.

Chlorophyll content can be calculated using formula as follows.
Chlorophyll a content ($mg \cdot L^{-1}$) = 12.72*A663-2.59*A645

Chlorophyll b content (mg·L-1) = 22.88*A645-4.67*A663
Total chlorophyll content ($mg \cdot L^{-1}$) = 20.2*A645+8.02*A663
Chlorophyll content on a fresh weight basis ($mg \cdot g^{-1}$ FW) = (C*V)/(W*1000)
A_{645} and A_{663}: absorbance values at 645 nm and 663 nm

FW: leaf fresh weight
C: chlorophyll content
V: total volume (ml) of each assay
W: fresh weight (g)

Photosynthesis Rate

Method - Estimate the maximum CO_2 assimilation rate (P_{Nmax}) and intercellular CO_2 concentration (Ci) by Portable Photosynthesis System (Li-cor).

Electrical Conductivity

EC is the measure of total dissolved salts in a solution. EC in this scenario measures cell leakage of electrolytes in distilled water solution. High EC values correspond with the amount of damage that has occurred in the treated plants plasma membrane. I.e. The more damage experienced from the glyphosate application, the more cell leakage which will occur and the higher EC values will be.

Method - Rinse fresh leaf discs with demineralized water and leave them floating in demineralized water. Electrolyte leakage was measured after 24 hours floating in RT using a conductivity meter. Demineralized water with no leaf discs is used as blank. Secondary conductivity is obtained after 72 hours of incubation at 95C instead of RT.

Electrolyte leakage (%) = $\frac{\text{EC 1} - \text{EC Blank1}}{\text{EC 2} - \text{EC Blank2}} \times 100\%$

Reactive Oxygen Species (ROS):

According to (Sewelam *et al.,* 2016), “during normal plant growth and development, ROS are produced in different cellular compartments in living cells with increased production under biotic and abiotic challenges. The rapid generation of reactive oxygen species (ROS) represents a common plant response to different biotic and abiotic stresses.”

Klaus *et al.,* (2004) also reported that “several reactive oxygen species (ROS) are continuously produced in plants as by-products of aerobic metabolism. Depending on the nature of the ROS species, some are highly toxic and rapidly detoxified by various cellular enzymatic and non-enzymatic mechanisms.”

Klaus *et al*., (2004) elaborated some more on ROS, stating that “plants have mechanisms to combat increased ROS levels during abiotic stress conditions, but in other circumstances plants appear to intentionally generate ROS as signalling molecules to control various processes including pathogen defence, programmed cell death, and stomatal behaviour.”

Method - Stain leaves with DAB solution by vacuum infiltration. Keep the stained leaves in dark for 6 hours. Destain leaves with destaining solution. Boil the leaves to bleach out chlorophyll and replace destaining solution with water. Perform visual observations on leaves and record values.

Results and Discussion

Phytotoxicity is another term for plant damage or plant injury that can result from the plant being susceptible to something which it comes into contact with. It can occur in crops after applications of chemical pesticides or fertilizers if dosage is incorrect or if environmental conditions following the application are conducive to inducing plant stress. Phytotoxic symptoms include leaf speckling, leaf margin necrosis (browning) or chlorosis (yellowing), brown or yellow leaf spots or patches, leaf cupping or twisting, plant stunting or in extreme cases plant death.

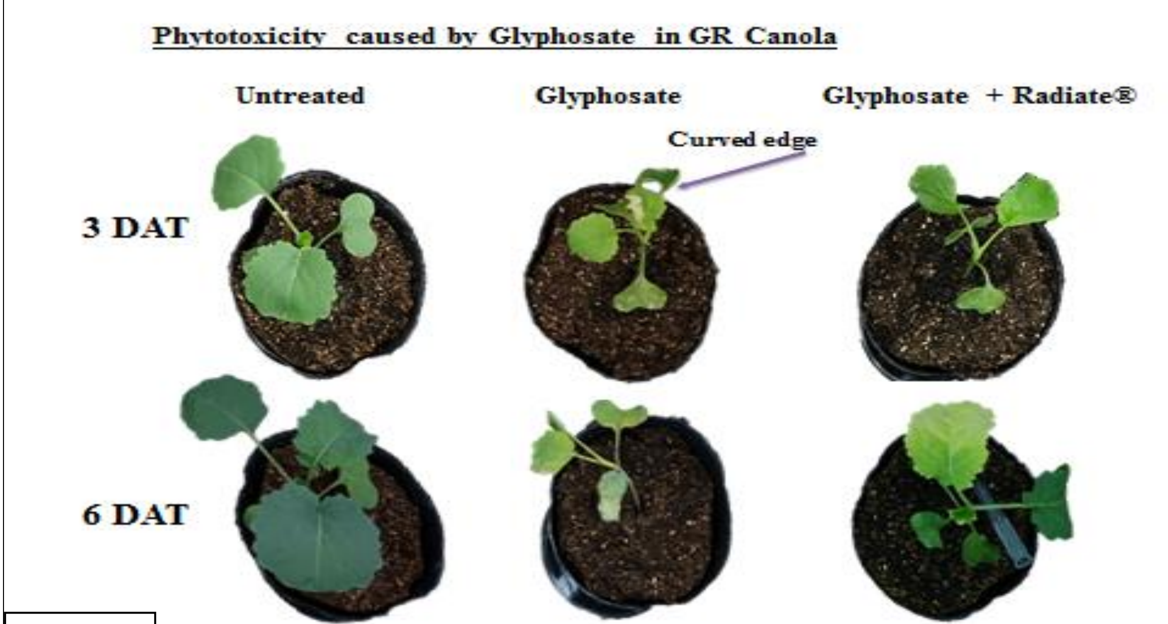

Figure 1.

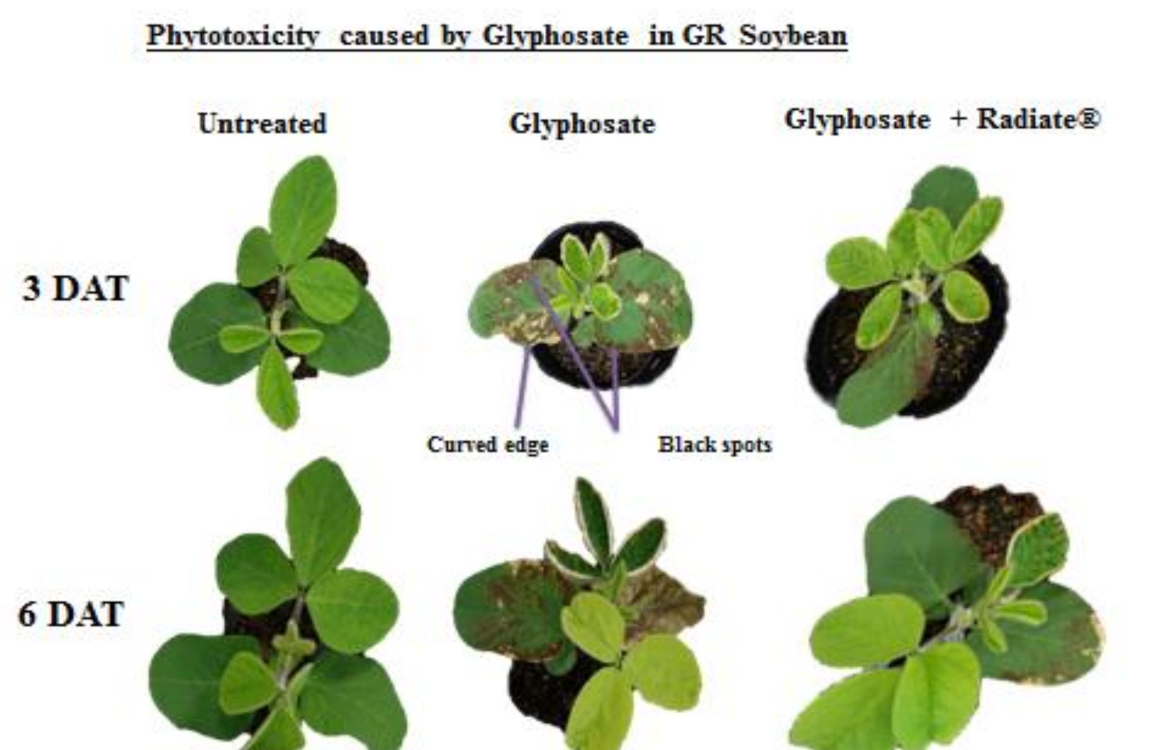

Figure 2.

Figures 1 and 2 are photographs of GR Canola and GR Soybeans @ 3 and 6 DAT. The untreated plants were included in these photographs to demonstrate the differences between GR plants which have had no glyphosate applied to them compared to ones that have. It would appear in both GR crops phytotoxicity was induced in the lab with the application of glyphosate. It is evident in the glyphosate alone and in the glyphosate/Radiate® combination treatments with symptoms of leaf speckling, leaf curing and leaf margin necrosis. At both 3 and 6 DAT the glyphosate + Radiate® combination has more leaf biomass in both GR crops compared to glyphosate alone. This indicates that plant physiological processes have been disrupted to a lesser extent with the addition of Radiate® to glyphosate.

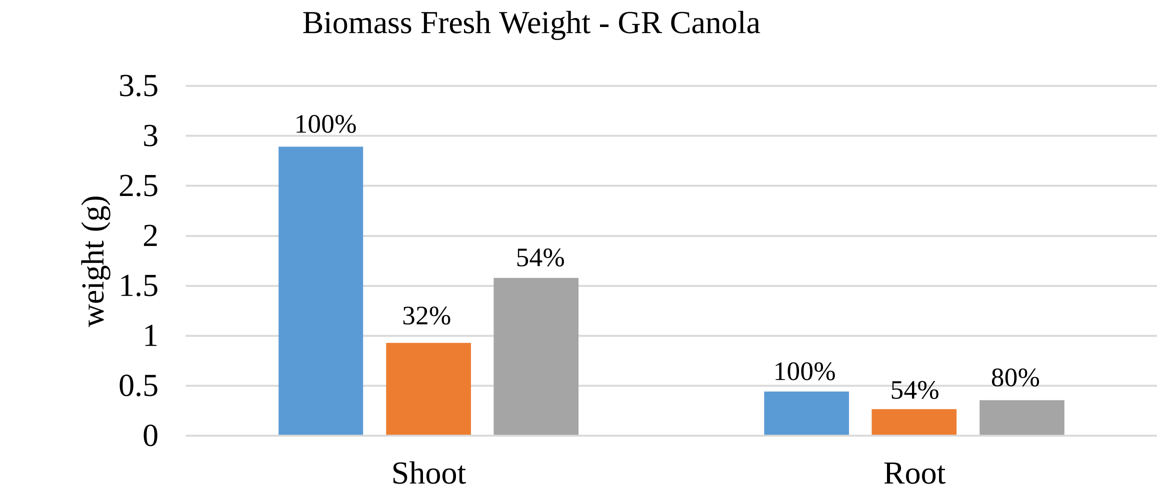

Figure 3.

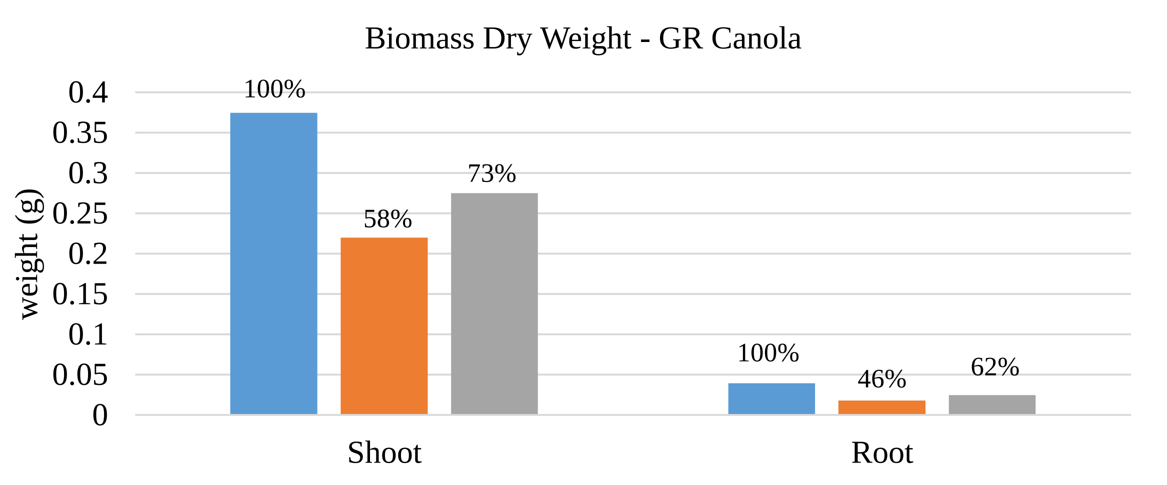

Figure 4.

Figures 3, 4, 5 & 6 are the results from biomass measurements taken on plant roots and shoots of both GR crops. Biomass measurements are not subjective and are a true indication of plant growth and development. GR Canola treated with Radiate®/Glyphosate (RDG) in Figure 3 improved fresh shoot weight by 22% and fresh root weight by 26% compared to glyphosate alone. GR Canola treated with RDG shoot and root dry weights, increased by 16% in roots, and 15% in shoots compared to glyphosate alone (Figure 4).

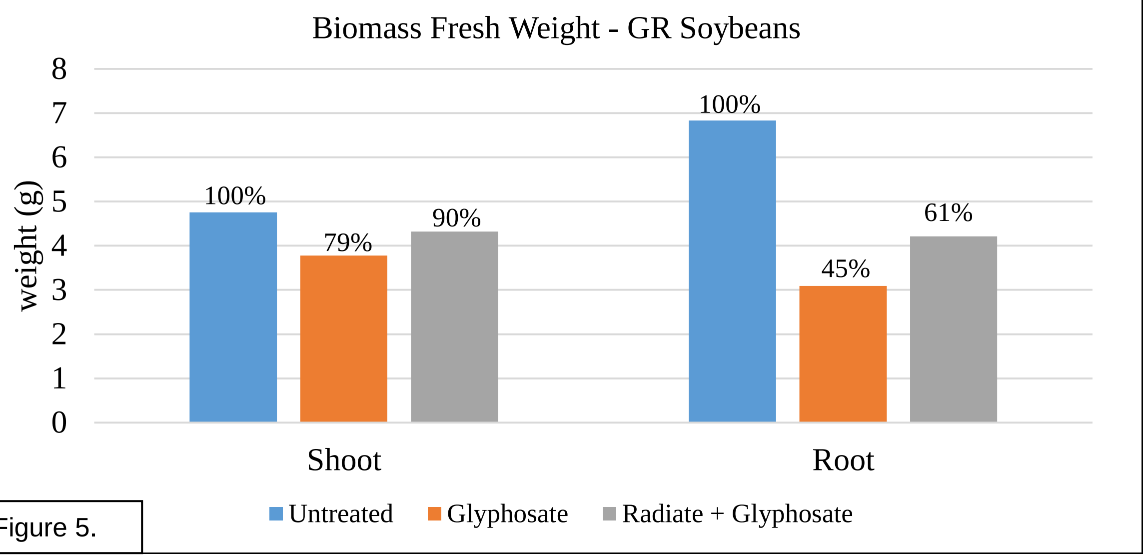

Figure 5.

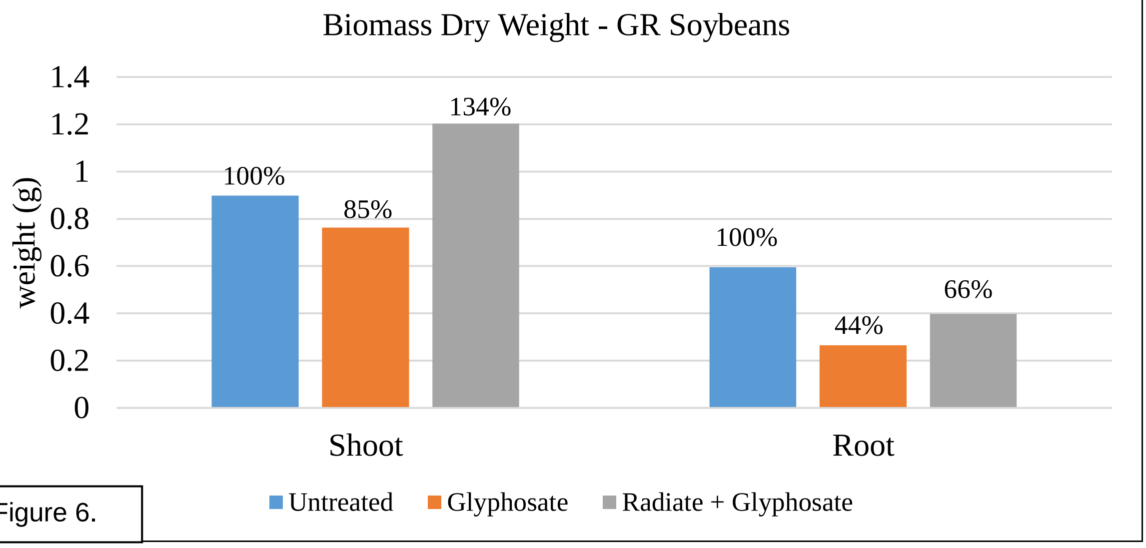

Figure 6.

The results and positive trends in shoot and root biomass weights observed in GR Canola treated with RDG were also seen in GR Soybeans treated with this combination. RDG in GR Soybeans improved fresh shoot weight by 11% and fresh root weight by 16% compared to glyphosate alone (Figure 5). When it came to biomass dry weight RDG treated GR Soybeans had a 49% improvement in dry shoot weight and a 22% improvement in dry root weight compared to glyphosate alone (Figure 6).

These biomass weight results provide supporting data which helps confirm the evidence that exogenous applications of Radiate® applied with the herbicide glyphosate does benefit GR crops. If there was no benefit to be had in GR crops from the addition of Radiate® to glyphosate this would have been reflected in the data and there would be very few differences in biomass weights if any between straight glyphosate and the combination of RDG.

Chlorophyll gives plants their green colour and is vital for photosynthesis. It is involved in channelling the energy of sunlight into chemical energy. Chlorophyll content was measured 3 DAT in both GR crops.

Figure 7 - In GR Canola there was 35% reduction in the chlorophyll content for the glyphosate only treatment when compared to the UTC. There was only a 14% decrease in chlorophyll content in the RDG treated plants suggesting that Radiate limited the destruction of chlorophyll significantly.

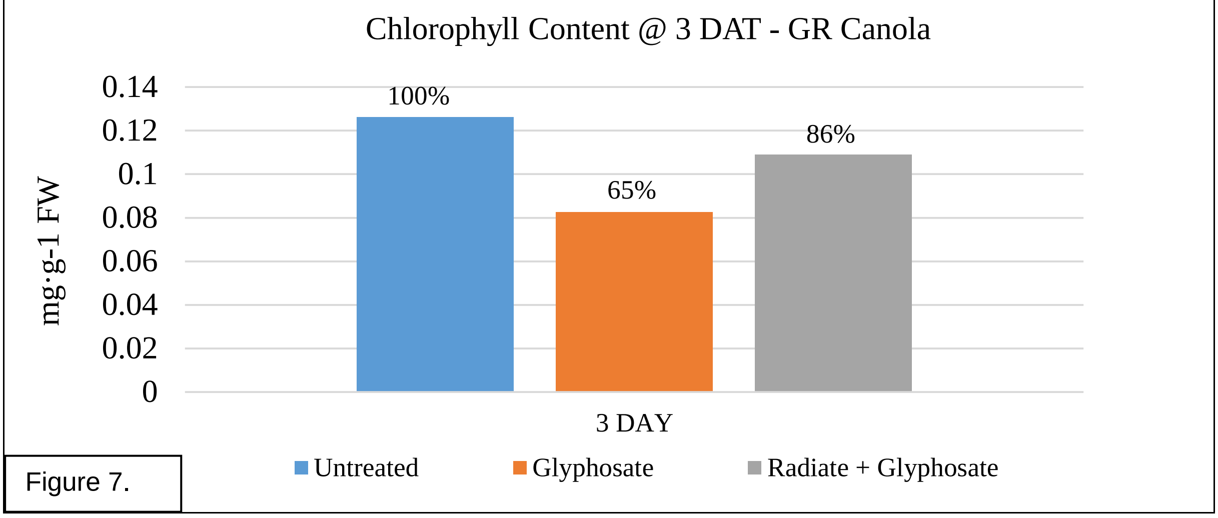

Figure 7.

Figure 8 - In GR Soybeans however there was 44% reduction in the chlorophyll content for the glyphosate only treatment when compared to the UTC. And only a 5% reduction in chlorophyll in the RDG treated plants. This suggests that the addition of Radiate nearly eliminated the negative effects of glyphosate.

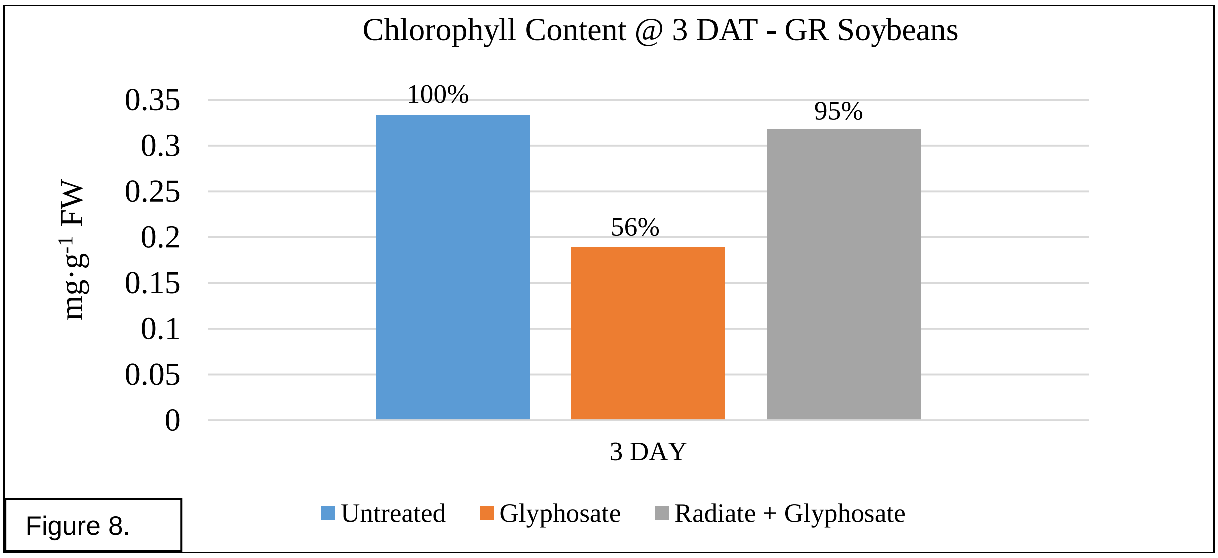

Figure 8.

With photosynthesis, chlorophyll absorbs energy and then transforms water and carbon dioxide into oxygen and carbohydrates. The process of photosynthesis converts solar energy into a usable form for plants which animals in turn eat, creating the foundation for life on earth for many species. Photosynthesis is one of the most important physiological processes which occur in plants due to its effect on plant growth and development.

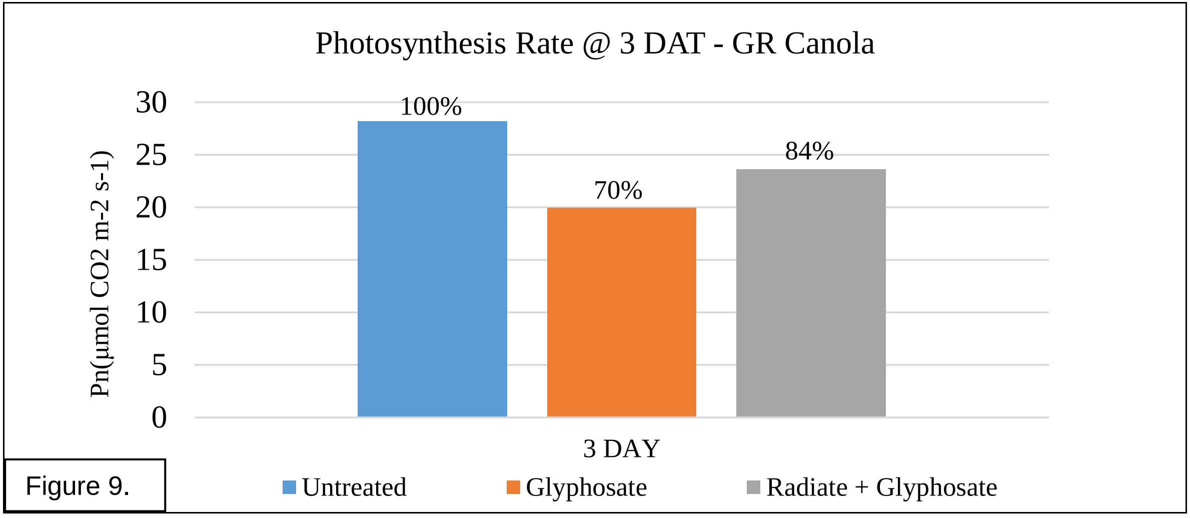

Figure 9.

Figure 9 – Photosynthesis rate was measured in GR Canola. The RDG treated plants have a 14 % improvement in photosynthesis rate compared to Glyphosate alone. This advantage could be useful in commercial situations when environmetal conditions slow crop growth or when herbicide phtotoxicity has been induced in GR crops.

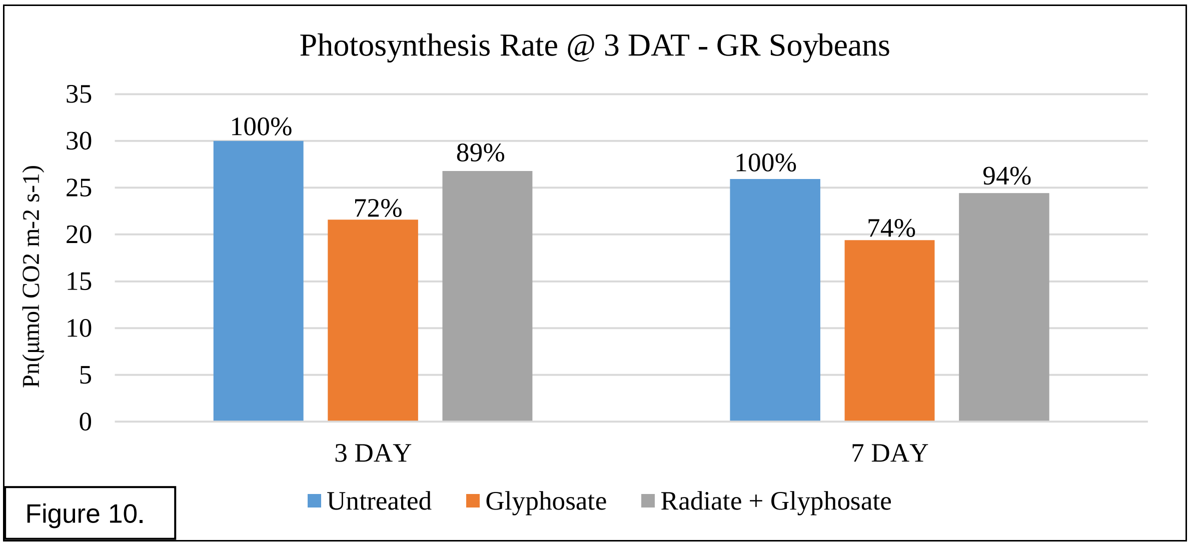

Figure 10.

Figure 10 – Photosynthesis rate was also measured in GR Soybeans. At 3 DAT the RDG treated plants have a 17 % improvement in photosynthesis rate compared to glyphosate alone and at the 7 DAT timing there is a 20% improvement in photosynthesis rate in RDG treated GR Soybeans compared to the glyphosate treatment. The improvement in photosynthesis rates observed in both GR crops treated with glyphosate and Radiate® is interesting. The data suggests it is possible for Radiate® to assist GR crops to recover faster from herbicide injury, enabling the plant to put this energy into producing foliage and yield instead of using it to recover from plant injury.

As previously discussed, Electric Conductivity (EC) in this scenario measures the cell leakage of electrolytes in a distilled water solution. High EC values correspond with the amount of damage that has occurred in the treated plants plasma membrane (CH Bio). I.e. the more damage experienced from the glyphosate application, the more cell leakage will occur and the higher EC recorded values will be. The EC value is always expressed as a relative ratio or percentage as compared to demineralized water blank.

EC Leakage @ 3 DAT - GR Canola leaves

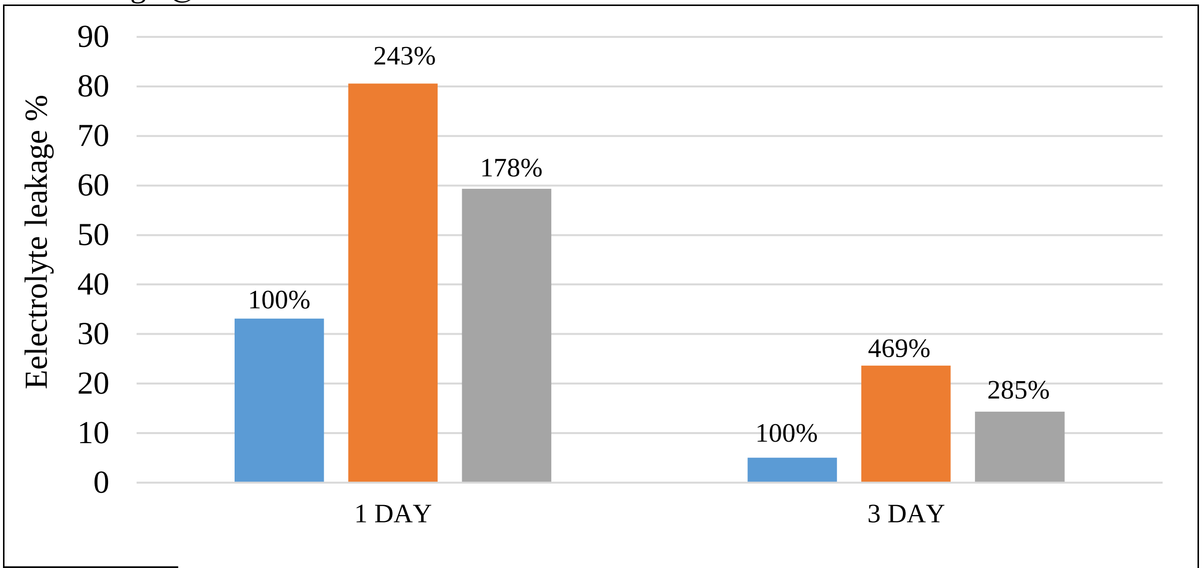

Figure 11.

Figure 11 - EC leakage was measured in GR Canola @ 1 DAT and @ 3 DAT. The results show that GR Canola treated with glyphosate had 2.43 times the electrolyte leakage of the untreated check. Addition of Radiate to the glyphosate application reduced electrolyte leakage by nearly one third. At 3 DAT, the level of EC leakage in the RDG treatment is only 40% of the glyphosate treatment, showing that beyond protection there is faster recovery.

EC Leakage @ 3 DAT - GR Soybean leaves

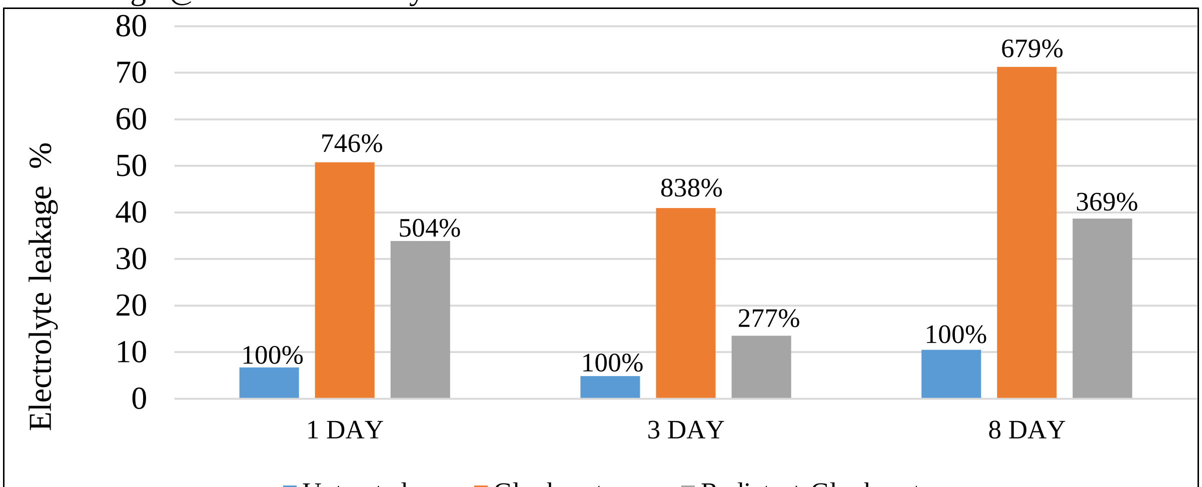

Figure 12.

Figure 12 - EC leakage was also measured in GR Soybeans @ 1, 3 and 8 DAT. The results show that GR Soybeans treated with glyphosate @ 1 DAT had 7.46 times the electrolyte leakage compared to the untreated check. And again the addition of Radiate reduced leakage by about

33%. At 3 DAT, the level of EC leakage in the RDG was only 1/3 the leakage of the glyphosate alone treatment, again showing faster recovery. At 8 DAT all samples showed an increase in leakage suggesting that time and degradation in an artificial environment was causing the samples to breakdown.

Reactive Oxygen Species (ROS).

According to Sewelam *et al.*, (2016), “During normal plant growth and development, Reactive Oxygen Species (ROS) are produced in different cellular compartments in living cells with increased production under biotic and abiotic challenges. The rapid generation of reactive oxygen species (ROS) represents a common plant response to different biotic and abiotic stresses.”

Gomes *et al.,(*2014) also stated that “Oxidative stress, more specifically lipid peroxidation, induced by glyphosate, is known to severely damage the cell integrity which may lead to cell death. More over, ROS production can negatively interfere with photosynthetic processes e.g. by decreasing chloropyll content, photochemical efficiency, and Carbon metabolism, leading to a reduction in plant growth.”

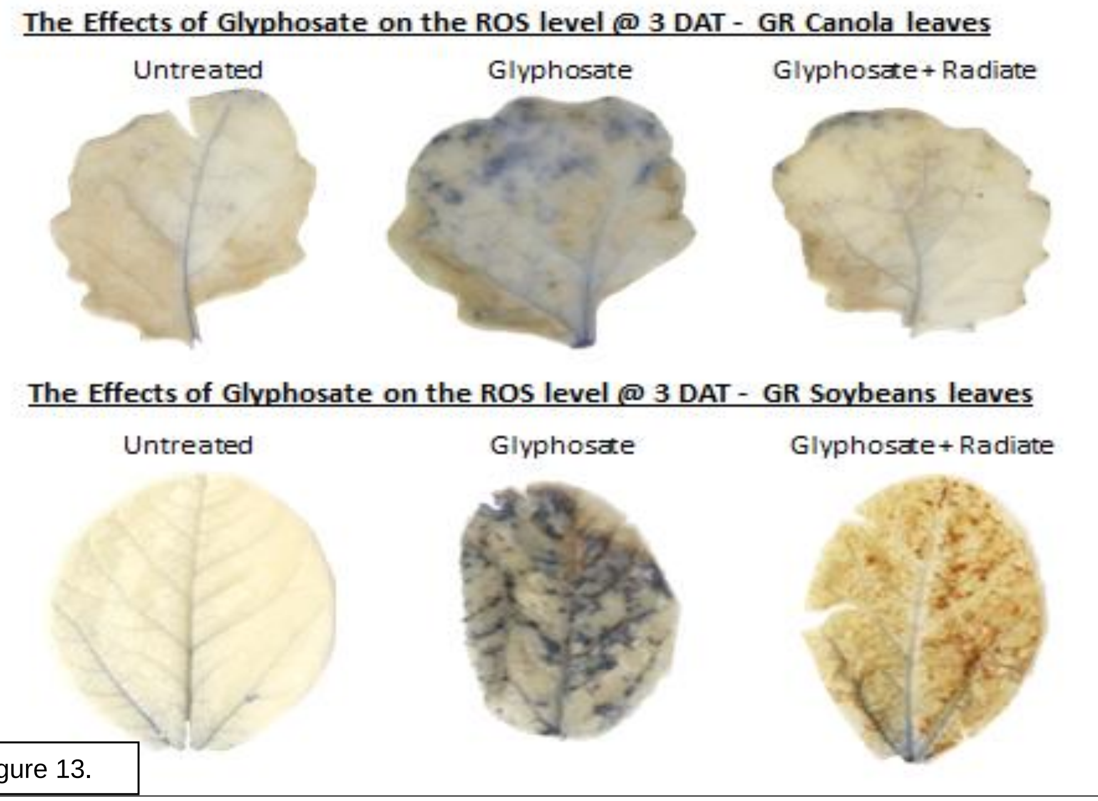

Figure 13.

ROS levels were measured in GR Canola and GR Soybeans during the trial period. Photographs were taken to demonstrate and document these effects in the two GR crops @ 3 DAT, see Figure 13. Treated plant leaves which show dark spots and dark patches in leaf tissue are expressing higher ROS levels, meaning these plants are under more abiotic/biotic stress. These dark spots and dark patches are mostly evident in the glyphosate treated GR Canola and in the glyphosate treated GR Soybeans. The symptoms are less pronounced in GR crops leaves which have had Radiate® and glyphosate applied to them at the same time, indicating this combination is helping to alleviate plant stress.

Conclusion

The non-selective systemic herbicide glyphosate is an extremely valuable tool used by farmers in modern agriculture to control unwanted weeds. Since its introduction, glyphosate has been instrumental in helping improve cultural practices in farming, which in turn has led to greater efficiencies and production increases in numerous crops around the world.

More recently, GR resistant technology in transgenic crops has made post emergent weed control a lot easier compared to what has been the case historically, however, since GR crops are not immune to the herbicidal effects of glyphosate (Reddy *et al*., 2004) or to phytotoxicity, there are products such as the plant growth hormone Radiate® which can be applied in conjunction with glyphosate that help GR crops recover faster from the herbicidal effects of glyphosate (Lee, 1980b) which in turn can help farmers maximise their crops yield potential.

In 2016, CH Bio Taiwan conducted laboratory testing on GR Canola and GR Soybeans treated with glyphosate, plus or minus the addition of Radiate® in the application. The tests conducted in Taiwan measured biomass fresh and dry weights of roots and shoots, the chlorophyll content of leaves, the photosynthesis rate, Electrical Conductivity (EC) leakage in leaves and Reactive Oxygen Species (ROS).

These testing procedures were deliberately selected and utilized for the experiment due to scientific peer reviewed papers confirming results from these tests are all good indicators of whether a GR crop is under stress or not. CH Bio and LPI also felt the data generated from these tests would provide supporting evidence, confirming if Radiate® can indeed mitigate the affect glyphosate applications and phytotoxicity can have on essential plant physiological processes which directly influence plant growth and development in GR crops.

When it came to the treatments that were applied in the trial to GR Canola and GR Soybeans, the combination of Radiate® with glyphosate was superior in performance in all of the metrics tested when compared to glyphosate applied on its own. Radiate® combined with the herbicide glyphosate is having positive effects when it comes to mitigating disruption of essential plant physiological processes that directly influence plant growth, development and ultimately yield in GR Canola and GR Soybeans.

The data also confirmed that Radiate® is not likely to stop phytotoxic symptoms occurring in GR crops from post emergent glyphosate applications, however; the addition of Radiate® to post emergent applications of glyphosate will help the plant recover faster from this condition, which can lead to higher yields. A strong healthy root system can be a significant advantage with this set of circumstances.

Data collected on the two GR crops in this trial demonstrated similar positive trends, giving a higher level of confidence in terms of validating this use pattern. If growing GR Canola in Canada or Australia, or GR Soybeans in the US or elsewhere; given the findings from this lab work, replicated trial work and multiple side by side field trials; the addition of Radiate® in post emergent glyphosate applications in GR crops is a technically sound agronomic option.

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