Assessing the Effectiveness of Fusion Gyp A & B on Soil Health and Crop Performance in Commercial Potatoes (Solanum tuberosum, L) Cultivated in Sodic Soil.

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Abstract

Salinity and sodicity adversely affect the soil and crop productivity across the globe due to the higher levels of salt. There are few ways to mitigate this issue and adding Gypsum is one of the common practices. This pot experiment was conducted to analyse the effects of liquid Fusion Gyp A&B on improving soil health and plant performance in potatoes grown in sodic soil. Single application of 1% Fusion Gyp A&B was done at planting. It was found that the soil in Fusion Gyp A&B treated pots started to flush Sodium and Chloride ions at significantly higher rate compared to control. Treated plant tissues had significantly higher amount of Silicon content while having significantly less amount of Sodium, Calcium and Chloride. Furthermore, treated plants resulted improved plant growth and development including plant height and stem thickness as well as potato yield. Potato tuber analysis showed that treated tubers had significantly higher amount of Silicon while having less Sodium, Chloride and Calcium. Moreover, electrical conductivity (EC) has reduced in the treated soil compared to the control pre-treatment soil EC. Overall, the application of Fusion Gyp A&B is a highly promising strategy soil health, plant growth and development and crop yield.

Keywords: Gyp A&B, Liquid Gypsum, Soil properties, *Solanum tuberosum*, Plant growth & development

1. Introduction

Soil salinity and soil sodicity are critical issues in the agriculture industry worldwide and it causes to reduce the soil productivity (El-Sharkawy et al., 2022). Salinity soil has higher level of water-soluble salt while sodicity soil has higher level of exchangeable sodium. Soil salinity directly affects the soil physical properties and therefore it affects the crop growth and performance. Furthermore, it is well documented that saline and sodic soil resulted numerous adverse effects to the soil nutrient and carbon recycling, soil structure as well as the organic matter decomposition (Wong et al., 2009).

In agriculture, gypsum is used as a soil amendment to assist in improving the soil structure in sodic and also magnesic soils (soils with a high magnesium content). Gypsum is comprised of calcium sulphate dihydrate and had been used in agriculture for more than 250 years (Chen and Dick, 2011). Gypsum not only improves soil structure, but it also can be a source of soluble of essential plant nutrients calcium and sulphur which both improve plant health. Gypsum works by separating and disturbing the clay sheets in the soil. Large calcium ions replace the small sodium ions between and clay sheets and move the clay sheets apart which breaks up the soil into smaller aggregates.

This process helps to prevent soil dispersion, reduces surface crust formation, increases seedling emergence and increases water infiltration rates in the soil (Chen and Dick, 2011). This process can also reduce the concentration of aluminium in the soil by replacing the aluminium ions with calcium and sulphur ions.

Potatoes plays a major role in the agriculture sector worldwide and potatoes are the fourth most important food crop in the world. Based on the volume of production and value of production potatoes are the most valuable vegetable crop in Australia (ABARES, 2019). South Australia is the biggest potato producer in Australia which accounts for 38% of the total production. There are three sectors in the Australian potato industry such as seed potatoes, ware potatoes and processing potatoes. (Blaesing , 2019).

The potato (*Solanum tuberosum, L.*) crop starts with vegetative growth followed by tuber induction and tuber enlargement. Nutrient uptake, Carbon assimilation and translocation take place throughout the entire cropping cycle. In addition, plant growth and development are strongly dependent on the sink-source interaction. Due to the shallow rooting system of potatoes, efficient use of nutrients is very low (Liu et al. 2015), therefore increasing root uptake of available macro and micro nutrients throughout the cropping cycle will assure good vegetative growth and optimum yield quality.

Dual Chelate fertilizer has created a 2-part liquid gypsum soil amendment which applied through the fertigation. First Gyp A is applied through fertigation and then Gyp B is applied 2 weeks later through fertigation. This effectively distributes the gypsum to where it is targeted in the subsoil. In this study, Fusion Gyp A&B was applied to the pots arranged in the greenhouse. In this study we used clay soil which had higher levels of Sodium and Chloride as well as poor soil structure. The aim was to improve the soil physical properties and crop performance.

2. Objectives

The specific objectives of this trial were to:

- Evaluate the crop growth and development
- Assess the impact of treatments on soil properties
- Study the nutritional status of soil and plant tissues
- Assess the run-off irrigation water at regular intervals to check the Sodium and Chloride levels in soil
- Evaluate the yields and tuber quality after applications of Gyp A &B

3. Materials and Methods

This trial was conducted in a greenhouse in Robinvale. There were two treatments and four replicates in this trial. Before starting the trial, soil sample was analysed by sending to an independent laboratory. There was a single application of Gyp A & B only at planting. Gyp A application was done at planting with the rate of 1% where Gyp B was applied two weeks after the application of Gyp A with the same rate. 25g of complete blue diamond granular fertilizer was added to each pot at planting and tuber initiation stage.

Sampling

Run-off irrigation water analysis was done fortnightly starting from fourth week of planting. Each pot was irrigated with 2L of water and then run-off water was collected from each control and treated pots separately. Water samples were sent to an independent laboratory (ALTSA - Analytical Laboratories & Technical Services Australia) to analyse the Chloride and Sodium levels as well as other nutrients in run-off water. Plant measurements including stem thickness, plant height and chlorophyll levels were measure after 8 weeks of planting. Furthermore, plant tissue testing (petiole testing) was done at the same time.

Potatoes were harvested after 14 weeks of planting and there were numerous yield data was recorded including tuber nutrient analysis, soil nutrient analysis, tuber weight, number of tubers and specific gravity.

4. Results

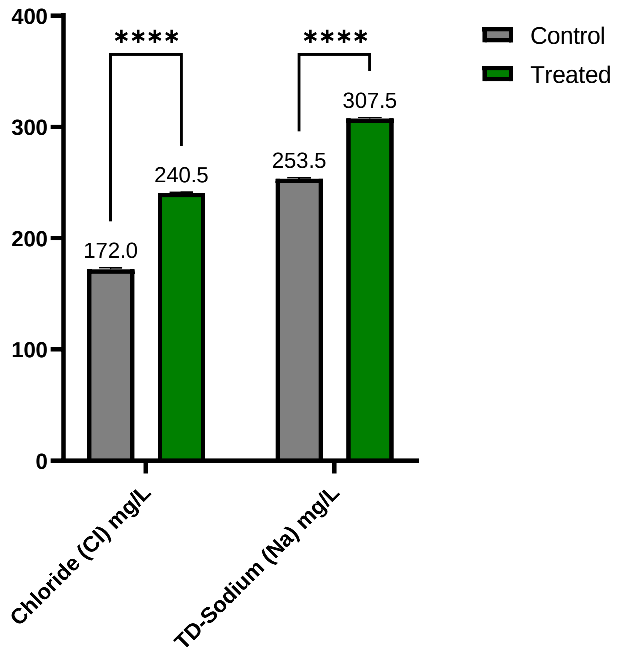

Figure *1(a)*: Chloride and Sodium content in run-off irrigation water collected from Gyp A&B treated pots and control pots after 4 weeks of treatment application. Asterisks represent statistical significance (** p,0.0001).**

Table 1: Other nutrient levels in run-off irrigation water collected from Gyp A&B treated pots and control pots after 4 weeks of treatment application.

Nutrient	Control	Treated
pH	7.7	7.7
EC	4.54	4.46
Nitrate Nitrogen	146	153
Ammonium Nitrogen	6.9	4.9
Hardness [as CaCO3]	2,100	1,700
TDS [EC estimate] waters	3,040	2,990
TD-Aluminium (Al)	<5	<5
TD-Boron (B)	1.82	1.12
TD-Calcium (Ca)	612	495
TD-Copper (Cu)	<0.1	<0.1
TD-Iron (Fe)	<5	<5
TD-Magnesium (Mg)	130	110
TD-Manganese (Mn)	<0.1	<0.1
TD-Molybdenum (Mo)	<0.1	<0.1
TD-Potassium (K)	89.6	71.5
TD-Phosphorus (P)	<5	<5
TD-Sulphur (S)	543	462
TD-Zinc (Zn)	<0.1	<0.1

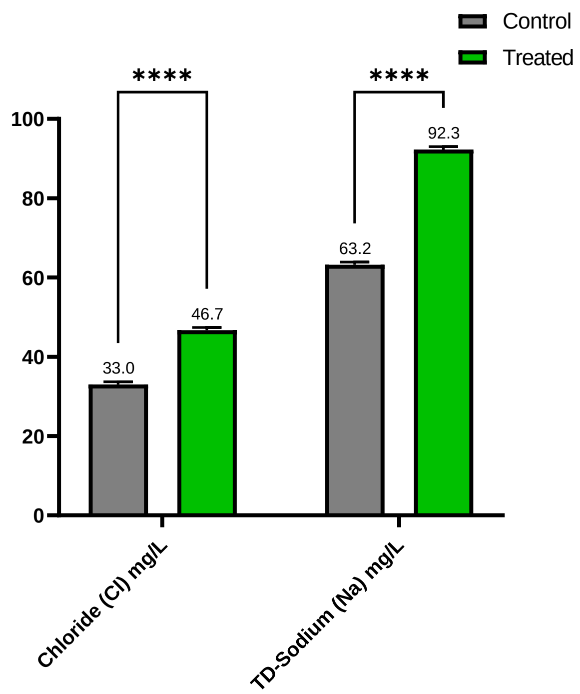

Figure *1(b)*: Chloride and Sodium content in run-off irrigation water collected from Gyp A&B treated pots and control pots after 6 weeks of treatment application. Asterisks represent statistical significance (** p,0.001).**

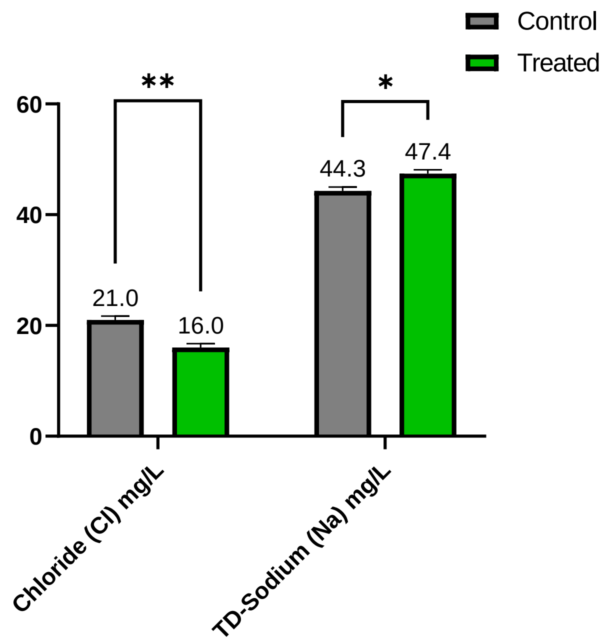

Figure *1(c)*: Chloride and Sodium content in run-off irrigation water collected from Gyp A&B treated pots and control pots after 14 weeks of treatment application. Asterisks represent statistical significance (* p,0.05; ** p,0.01).

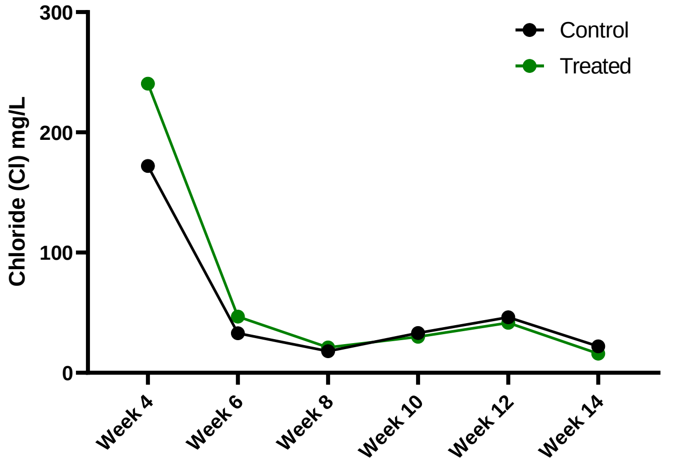

Figure *2*: Chloride level changes in run-off water collected from Gyp A&B treated and control pots from week 6 to 14.

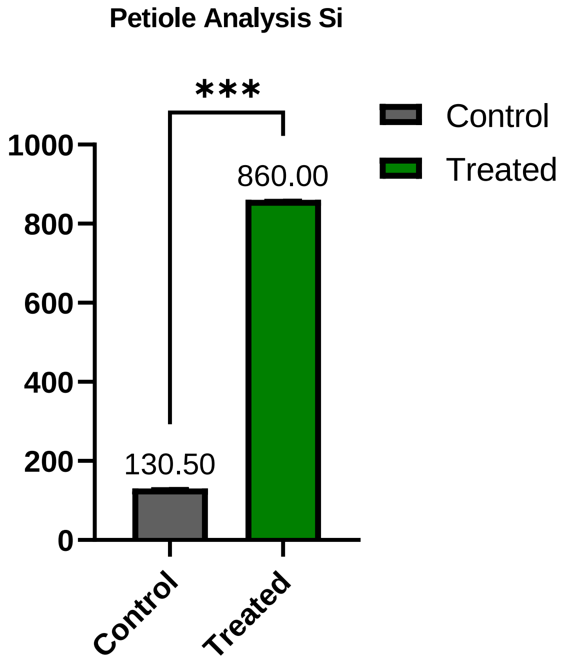

Figure *4*: Silicon level in petioles collected from Gyp A&B treated and control pots in week 8. Asterisks represent statistical significance (* p,0.001).**

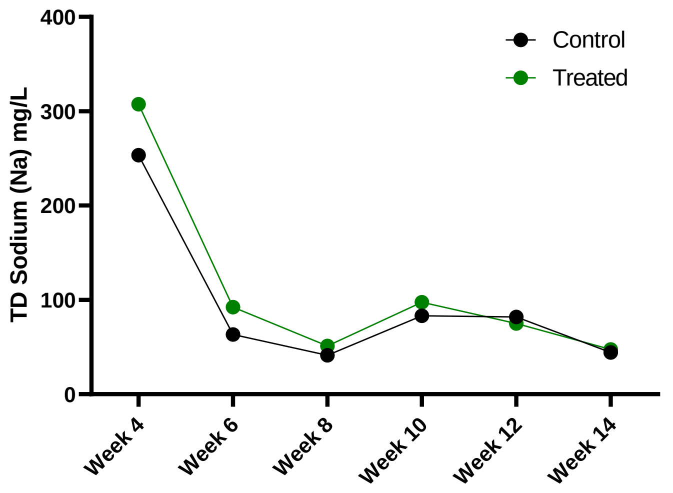

Figure *3*: Sodium level changes in run-off water collected from Gyp A&B treated and control pots from week 6 to 14.

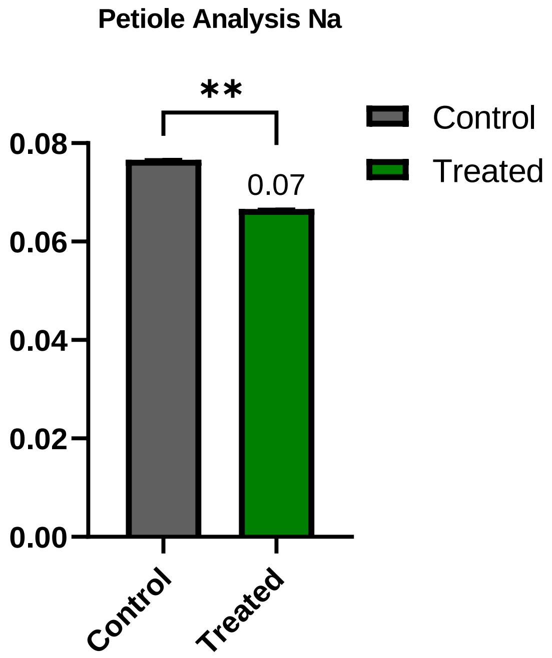

Figure *5*: Sodium level in petioles collected from Gyp A&B treated and control pots in week 8. Asterisks represent statistical significance (p,0.01).**

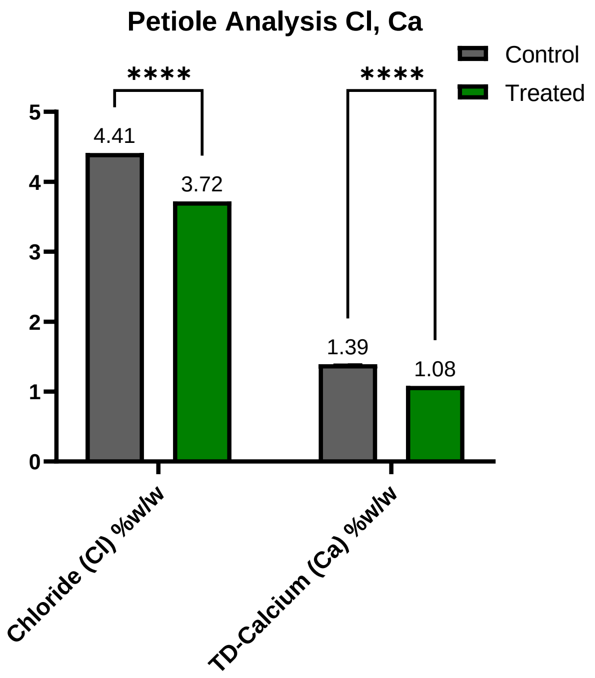

Figure *6*: Chloride and Calcium levels in petioles collected from Gyp A&B treated and control pots in week 8. Asterisks represent statistical significance (**** p,0.0001).

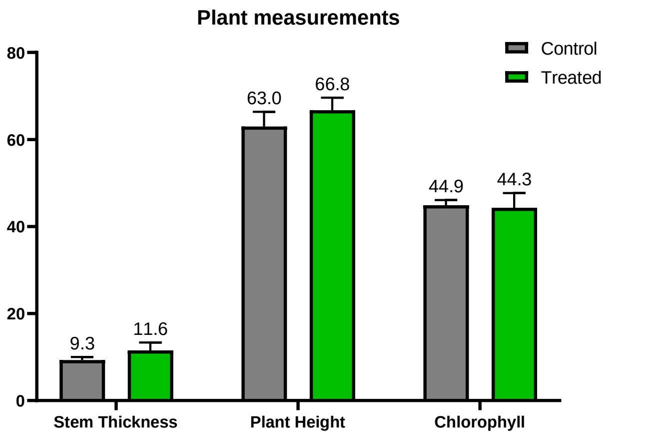

Figure *8*: Effects of Gyp A&B treatments on plant height, stem thickness and chlorophyll levels in week 8.

Figure *7*: Visual comparison of plant growth in control (A) and Gyp A&B (B) treated pots in week 8.

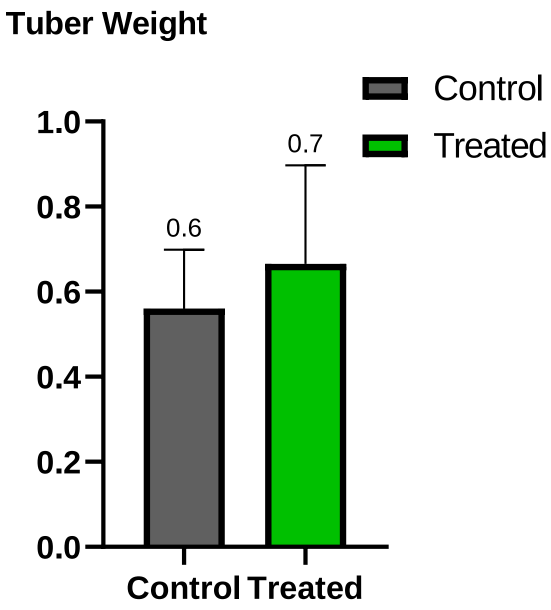

Figure *9*: Potato tuber weight in control and treated pots at harvesting.

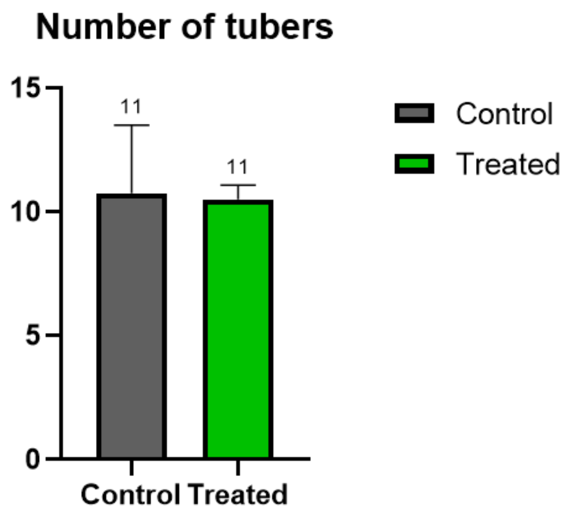

Figure *10*: Number of tubers in each pot at harvesting.

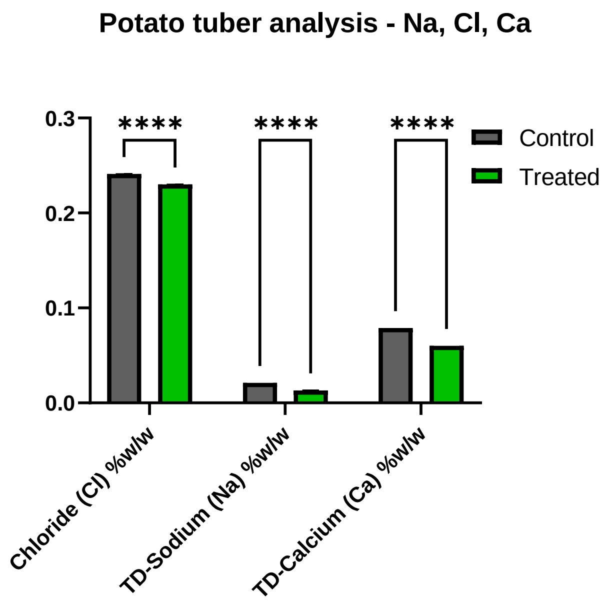

Figure *12*: Sodium, Chloride and Calcium levels in potato tubers collected from control and treated pots at harvesting. Asterisks represent statistical significance (** p,0.0001).**

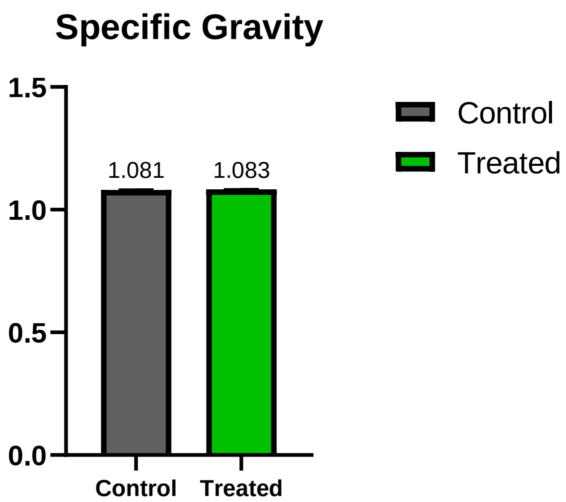

Figure *11*: Specific gravity of potato tubers collected from each pot at harvesting.

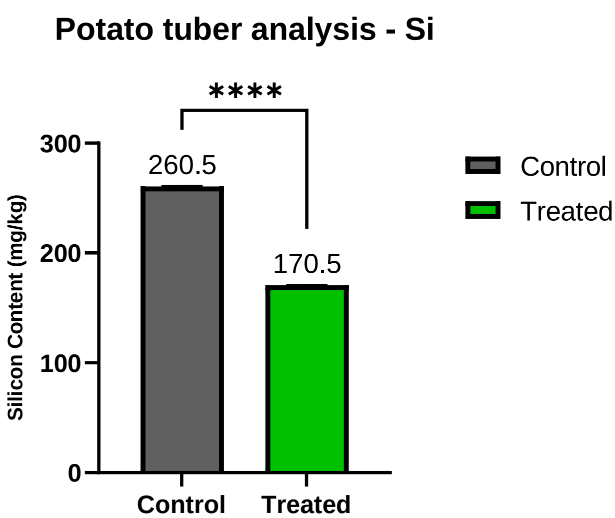

Figure *13*: Silicon content in potato tubers collected from control and treated pots at harvesting. Asterisks represent statistical significance (** p,0.0001).**

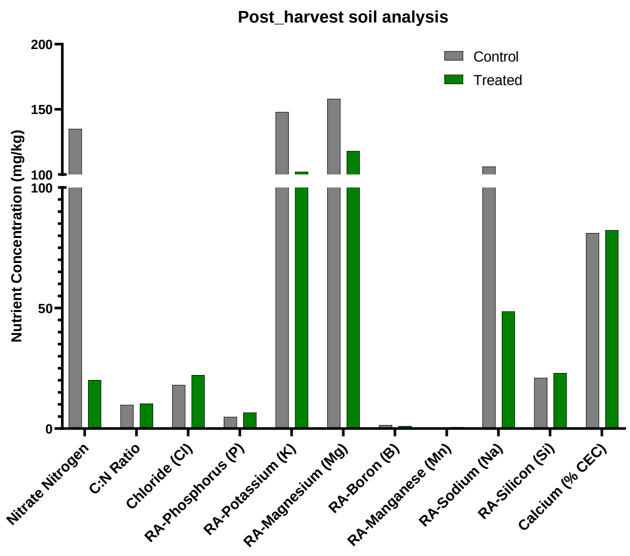

Figure *14*: Soil nutrient analysis at post-harvest in treated and control soil.

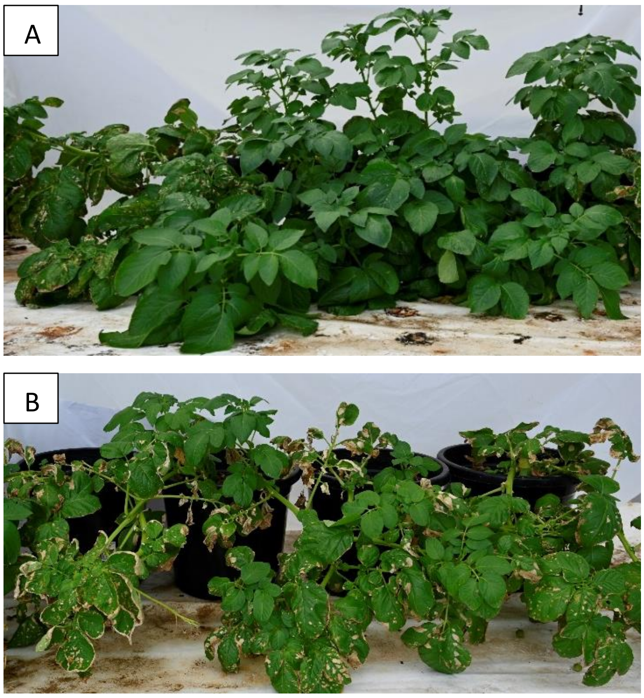

Figure *15*: Visual comparison of plant growth at week 12.

Table 2: Comparison of pre-treatment and post-harvest soil analysis results in control and treated pots.

	Control		Treated	
	Pre-treatment	Post-harvest	Pre-treatment	Post-harvest
pH [1:5 H2O]	7.5	7.2	7.5	7.2
pH [1:5 CaCl2]	7.4	7.1	7.4	7
EC [1:5 H2O]	3.24	2.29	3.24	1.84
Chloride (Cl)	519	18.1	519	22.1
RA-Sodium (Na)	22,400	106	22,400	48.6
RA-Silicon (Si)	857	21	857	23
Calcium (% CEC)	78.7	81.1	78.7	82.3

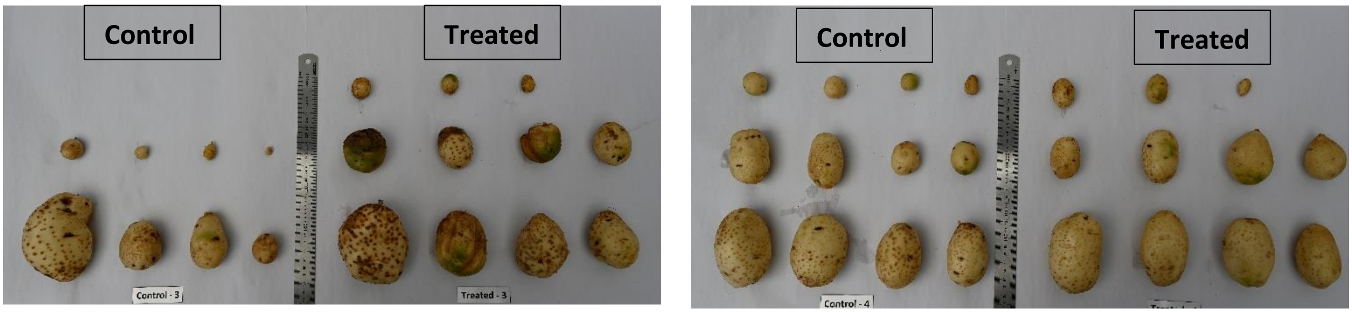

Figure *16*: Visual comparison of potato tubers collected from control and treated pots.

Discussion

Figure 1 shows the changes in Chloride and Sodium level in run-off irrigation water that collected from Gyp A&B treated pots as well as control pots from week 4 to week 14. In week 1 (Figure 1a), water collected from treated pots had significantly higher levels of Chloride and Sodium compared to the control. This can be explained by the activity of Gyp A&B in the soil. Once Gyp B is applied 2 weeks later from Gyp A application through fertigation and converts the liquid calcium sulphate into a solid through an oxidation reaction. Sodic soil has higher level of Sodium ions and theses Sodium ions have bind with the clay particles. Once Gyp A&B applied, Calcium ions replace the Sodium ions and bind with clay particles by leaching Sodium ions through the soil (Bello, Alayafi, AL-Solaimani, & Abo-Elyousr, 2021, Rengasam, Smith, & North, 2010). This explains why the run-off water collected from Gyp A&B treated pots had higher amount of Sodium. Run-off water analysis was continued until harvesting and collected water samples in every second week. The results showed that until the week 10, water samples collected from Gyp A&B treated pots had highest amount of Sodium and Chloride levels than control (Figure 2 & 3).

Furthermore, Gypsum is Calcium Sulphate and when gypsum is applied to the top soil prior to planting or shortly after harvest. When applied to the top soil, the gypsum then leaches down into the subsoil through irrigation and rainfall where its benefits can take effect. Gypsum can also be deep ripped into soil to target the subsoil directly if there are hard clay pans. Deep ripping can also break up any hard soil and provide aeration. Gypsum can also be applied as a liquid soil amendment which works faster and more efficient.

It is well documented that application of Gypsum can improve the nutrient availability in soil and improve the plant nutrient uptake (Bello, Alayafi, AL-Solaimani, & Abo-Elyousr, 2021). Similar to that, this study resulted that water collected from Gyp A&B treated pots had less amount of nutrients compared to the control (Table 1). Plant tissue testing was done by analysing petioles and results showed that petioles collected from Gyp A&B treated pots had significantly higher levels of Silicon but significantly less amount of Sodium, Chloride and Calcium (Figure 4, 5 & 6). It can be explained that the Calcium ions have replaced the Sodium ions in the soil and bound with clay particles. Silicon (Si), although a micro element, is one of agriculture's key plant nutrients due to its beneficial effects on plants with research specifically being conducted in the benefits of Silicon is managing and assisting in the tolerance of both biotic and abiotic stresses (Luyckx, Hausman, Lutts and Guerriero, 2017). Along with management in stress conditions, Si has also been proven to promote greater yields at a greater quality as a result of increased stress tolerance and increased beneficial plant physiology (Korndörfer and Lepsch, 2001). Moreover, high amount of Chloride was recorded in control could be due to the high levels of Chloride ions in control soil.

In week 8, plant measurements including plant height, stem thickness and chlorophyll content were measured. Gyp A&B had the higher plant height and stem thickness compared to control plants. However, there was no considerable difference in chlorophyll levels in control and treated plants. Gyp A&B application has reduced the Sodium and Chloride ions from the soil and improved the nutrient availability for plants. Therefore, this could be the reason for the improved plant growth including plant height and stem thickness in treated plants. It is reported that Gypsum application has improved the soil structure and thereby plant growth (Fisk, 2019, Lee & Mudge, 2013). In addition, Gyp A&B treatment added extra Sulphur to the soil and Sulphur is an essential element for chlorophyll and amino acid formation. At the same time photos were taken for the visual comparison of plant growth and it showed that treated plants were bigger in size and more vigorous compared to control (Figure 7).

At harvesting, tuber weight, number of tubers, specific gravity of tubers and tuber analysis was conducted to study the effects of Fusion Gyp A&B on potato yield increment. Potato tubers collected from Gyp A&B treated pots had higher yield compared to control (Figure 9), however treated plants had sightly a smaller number of tubers compared to control (Figure 10). Figure 16 shows the comparison of potato tubers collected from control and treated pots. There was no significant difference was observed in specific gravity between control and treated potatoes.

It is known that the nutrients already in potato tubers are the main source of energy which is used during plant germination. There are several factors that affect potato emergence and establishment, including seed quality, disease infestation, herbicide damage, size of seed pieces and weather conditions (S.V. Murashev, S.D. Kiru, V.G. Verzhuk, A.V. Pavlov, 2020). Nutrient analysis of potato tubers showed that potatoes harvested from treated pots had significantly less amount of Chloride, Sodium and Calcium, but significantly higher amount of Silicon compared to control (Figure 12 & 13).

Soil analysis was done after the harvesting to check the nutritional status of control and treated soils as well as to compare with pre-treatment soil analysis results. The results showed that control soil had more Nitrogen, Potassium, Magnesium and Sodium compared to control (figure 14). Gypsum application caused to improve the soil structure and nutrient availability for plants and that could be the reason that treated soil had less nutrients compared to control. Pre-treatment and post-harvest soil analysis comparison was done to check the soil nutritional status of the soil before the trial and after the trial. It showed that Fusion Gyp A&B treated soil has reduced the soil electrical conductivity (EC) (Table 2). Numerous studies have proven that Gypsum application significantly reduced the soil EC (Amezketa, Aragüés, & Gazol, 2005). Therefore, the decrease in EC can be explained by the impact of Fusion Gyp A&B on reducing soil salinity.

6. Conclusion

This experiment was carried out to assess the effectiveness of Fusion Gyp A&B on improving soil health and crop performance in potatoes grown in salt affected soil. Gyp A&B treated soil significantly leached Sodium and Chloride from the soil while leaching less nutrients compared to the control soil. Treated plant tissues had significantly higher amount of Silicon content while having significantly less amount of Sodium, Calcium and Chloride. Furthermore, treated plants resulted improved plant growth and development including plant height and stem thickness as well as potato yield. Potato tuber analysis showed that treated tubers had significantly higher amount of Silicon while having less Sodium, Chloride and Calcium. Moreover, treated soil had less electrical conductivity (EC) compared to the control and compared to the pre-treatment soil EC. Therefore, it can be concluded that the application of Fusion Gyp A&B significantly improved the soil health, plant growth and development and potato yield.

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