AQUA SALVEO MICRONUTRIENT FERTILISER
PRODUCT INFORMATION

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1 BACKGROUND AND CONTEXT

1.1 Introduction

Agriculture is one of the largest sectors of economies that sustain the livelihood of many communities in the world. It also happens to be the sector that is heavily dependent on the availability of water and nutrient ions to thrive. These valuable resources, however, are under threat from climate change, climate variability and teeming human population which have emerged as formidable challenges that humanity will face for many years to come. The impact of climate change is expected to extend to water quantity and quality; land degradations and nutrient loss, food security; ecological and biodiversity systems; human health, human settlement and migration. General predictions from climate models indicate scenarios of increased temperatures, increased frequency of drought, increased incidence of floods and climate variability and extremes across the different locations on the globe. These conditions have severe implications on agriculture productivity and food security in general.

Plant nutrition is important for higher agricultural productivity to feed the rising consuming human population. Soils are largely the only source of nutrient ions for plants but over the past thousands of years, the amount of nutrients removed by plants are not correspondingly replaced by inputs into the soil, naturally or externally. Traditionally, inputs of plant nutrients into agricultural systems is predominantly from bulk inorganic external fertiliser application either through the leaves or the soil. The major challenge from bulk fertiliser application is low bioavailability and uptake by resulting in poor uptakes efficiency and environmental contamination, depending on the inorganic fertiliser size, composition, concentration and mode of application. Alternative technologies with superior nutrient use efficiencies are required to address these concerns.

Rising water temperatures from global temperature changes, heavy intense downpours through floods and incidence of droughts can alter the quality of our drinking and irrigation water with the consequent effects of severely reduced crops, livestock and forest productivity. Furthermore, bacteria and viruses thrive in these new conditions and can create numerous conditions which are favourable for disease infestation in croplands, forest plantations, livestock housing units and food processing and packaging units. These scenarios could also lead to increasing demands for these resources which are already limiting to maintain productivity. Smart approaches that increase plant and livestock productivity through efficient water and nutrient use, are therefore required if agriculture is to meet the food demand of a mushrooming human population.

Recent studies have indicated that plant nutrient ions in nano concentration (*10-100 nm*) have a significant influence on plant physiological processes, growth and development. A nanotechnological approach where plants and livestock are provided with minute amounts of micronutrients is one approach that has the potential to stimulate crop, forest and livestock productivity and provide effective solutions to the multiple agriculture-related problems.

1.2 About Aqua Salveo Micronutrient Fertiliser

Aqua Salveo Micronutrient Fertiliser is a product manufactured by a South African Company and approved by the South African Bureau of Standard (SABS) and the national Department of Agriculture, Forestry and Fisheries (DAFF) for human application.

The active micronutrient ingredients of Aqua Salveo Micronutrient Fertiliser are metal salts of Copper (Cu) and Zinc (Zn) manufactured through nanotechnology. The quantity of ingredients in concentrated and diluted forms are presented in the table below:

Ingredient	Concentrated *(g litre^{-1})*	Diluted *(g litre^{-1})*
Zn	55.85	0.010
Cu	14.44	0.0026

The two elements work in synergy, to produce an effective growth stimulating product for increased physiological activities, productivity, health and effective management of diseases. It is odourless and tasteless and can be used for irrigation in cropping systems. An ongoing experiment on the plant revealed that after 10 years, the quality of the fertiliser remains unchanged.

Micronutrient

Zinc: This is an important plant trace nutrient involved in many important components of various enzymatic metabolic reactions that drive several key plant physiological pathways in plants. This includes the synthesis of carbohydrates, protein, chlorophyll formation and photosynthesis. Zinc is also highly suppressive against fungal and bacterial pathogens including those pathogenic to plants.

Copper: Similar to zinc, copper is required for many enzymatic activities in plants and chlorophyll and seed production. The deficiency of copper can lead to increased susceptibility to diseases and lodging in cereal crops due to impaired photosynthetic activities and subsequent yield loss in crops. In mammals, Copper is involved in the maintenance of immunity and fertility, formation of melanin, and the promotion of consistent pigmentation. Copper is used by the body to manufacture numerous enzymes, many of which work as antioxidants. The combined application of both copper and zinc suppresses toxins produced by soil-borne fungal pathogens responsible for inducing diseases.

Water is a key resource in agricultural and forestry production, influencing productivity and sustainability. The influence of water is determined by both quantity and quality. With Aqua Salveo Micronutrient Fertiliser being a water product fortified with valuable micronutrients, its application in plants is beneficial. Based on these attributes, several trials have been established to ascertain the effectiveness of the product and its potential contribution in climate-smart approaches to sustain crop and livestock production in an era of a changing climate.

2.0 LITERATURE

3.0 OBJECTIVES & SELECTED PLANTS

3.1 Main objective

The main objective of this submission is to promote the application of Aqua Salveo Micronutrient Fertiliser, a nano-manufactured product in plant production systems.

4.0 USAGE

4.1 Specific plant application

- Field crops
- Vegetable crops
- Fruit crops
- Pasture crops
- Plantation crops
- Forestry
- Seedling nurseries
- Ornamental crops

- 1.0 litre of Aqua Salveo Micronutrient Fertiliser treats 5000 litres of water
- The product can be applied through irrigation or foliage
- The product should be applied in combination with other fertilisers, particularly organic fertilisers.
- Works best with organic fertilisers

- ***Application rate:***
  - For annual crops: Once a week for 4 weeks followed by once in 2 weeks till maturity.
  - For perennial crops: Once a week at the onset of flowering and flowering, followed by once in 2 weeks.
  - For grasses: Once in two weeks.

- **Store in cool place**

5.0 PRELIMINARY EXPERIMENT

The following experiments on the impact of Aqua Salveo Micronutrient Fertiliser commenced in 2019:

1) Influence of Aqua Salveo Micronutrient fertiliser on tomato root biomass production under a greenhouse condition
2) Aqua Salveo Micronutrient Fertiliser and inorganic nutrient solution impact on growth and yield of tomato under field experimentation.
3) Impact Aqua Salveo micronutrient fertiliser and inorganic nutrient solution on growth and yield of tomato under shade net condition.
4) Impact Aqua Salveo Micronutrient Fertiliser and inorganic nutrient solution on growth and yield of tomato under organic farming conditions.
5) The impact of Aqua Salveo Micronutrient Fertiliser on growth of tomato and green peas.
6) Potato tuber yield response to Aqua Salveo micronutrient on a high fertile soil.

5.1. AQUA SALVEO MICRONUTRIENT FERTILISER IMPACT ON TOMATO ROOT BIOMASS

5.1.1. Introduction

Tomato is a major vegetable crop and it is produced under commercial and subsistence farming systems. Crop yield is however negatively affected by several factors including the constraints of heat stress, water stress, plant nutritional stress. Addressing these constraints through effective plant nutrition will contribute to improved tomato productivity under stressful conditions. The objective of this study was to assess the impact of Aqua Salveo Micronutrient Fertiliser application on tomato root biomass production.

5.1.2. Materials and Methods

The experiment was carried out under controlled greenhouse conditions. Tomato seedlings were treated with a solution of Aqua Salveo Micronutrient Fertiliser solution (using a commercially recommended concentration of 3 drops (0.09ml) Aqua Salveo Micronutrient Fertiliser per 1 litre of water and then planted in pots filled with soil from the field of tomato farmers. Another set of plants were similarly planted and were watered with ordinary water without Aqua Salveo Micronutrient Fertiliser. The treatments were replicated four times. The plants were irrigated with the solution once a week. Root biomass data was carried out 6 days after transplanting by digging the whole plant. The root was separated from the shoot, washed under tap water over a sieve to recover broken roots. The two plant fractions were dried in an oven at 60 ^{o}C until constant weight and biomass weight was recorded. Root mass based on appearance.

5.1.3. Results

Treated plants also had high root mass as compared to control plants (Figures 3 and 4).

Figure 1a. Shoot of Aqua Salveo Micronutrient Fertiliser Micronutrient Fertiliser -treated (left) and non-treated tomato plants

Figure 1b. Roots of non-treated plants (left) and Aqua Salveo Micronutrient Fertiliser-treated (right) tomato.

5.1.5 Concluding remarks:

The enhanced root growth resulting from Aqua Salveo Micronutrient Fertiliser treatment was clearly demonstrated in this preliminary trial.

5.2. TITLE: TOMATO GROWTH RESPONSE TO AQUA SALVEO MICRONUTRIENT FERTILISER AND INORGANIC FERTILISER

5.2.1. Objectives

1) Assess the impact of the application of Aqua Salveo Micronutrient Fertiliser at a standard rate on tomato growth, phenology and yield.
2) Determine the impact of Aqua Salveo Micronutrient Fertiliser application on residual soil concentration of copper, zinc and silver in fruit, biomass and soil.

Location: Blessman International (BI): Mountain View Research Farm, Mokopane Municipality in the Limpopo province of South Africa
Season: The 2019-2020 growing season
Experimental unit: Field conditions

5.2.2. Treatment

Treatment: The following three treatments were examined:

1) Aqua Salveo Micronutrient Fertiliser applied at 5ml/50 litter water through fertigation
2) Standard fertiliser applied at a standard rate through fertigation
3) Control treatment with only water applied through fertigation.

5.2.3. Materials and methods

Experimental site:	Blessman International (BI): Mountain View Research Farm, Mokopane, South Africa.
Soil sampling:	Preplant soil sampling at 0-30 cm and 30-60 cm depths.
Test crop:	Tomato, Variety Rodale
Plant data collected:	Plant height, flowering, stem diameter, fruit yield and fruit diameter.

5.2.4. Preliminary Results

Fruit yield
From the very first harvest which occurred 102 days after transplanting, the fruit yield of the Aqua Salveo Micronutrient Fertiliser treated plants was 5.53 kg per 5 plants compared to 2.95 kg per 5 plants of the fertiliser treated plants. This constitutes an approximately 87.8% increase.

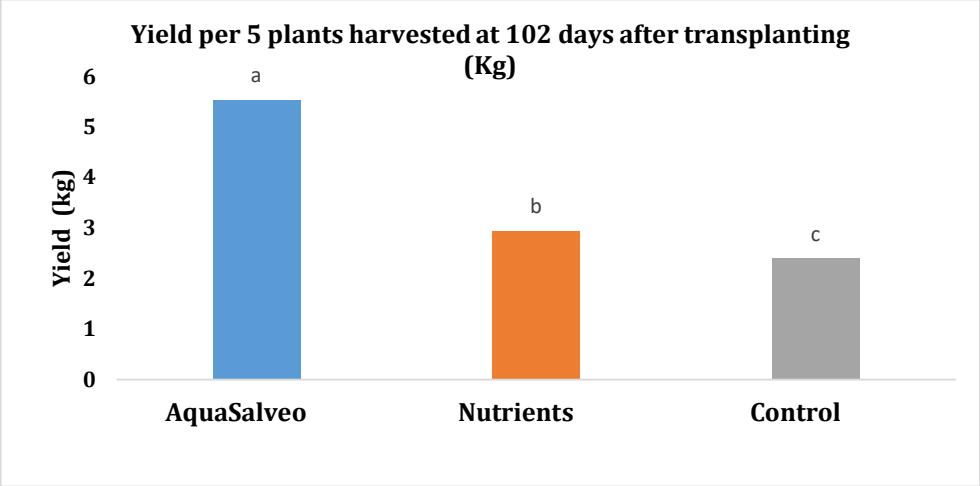


***Figure 2**. First yield per 5 plants harvested at 102 days after transplanting (kg).*

The yield of the Aqua Salveo Micronutrient Fertiliser plant was 130% higher than the control plants that neither received the Aqua Salveo Micronutrient Fertiliser nor a nutrient solution.

Fruit diameter

The fruit diameter of the Aqua Salveo Micronutrient Fertiliser treated plants was 100.5% higher than the fertiliser treated plants and 155.3% higher than the control.

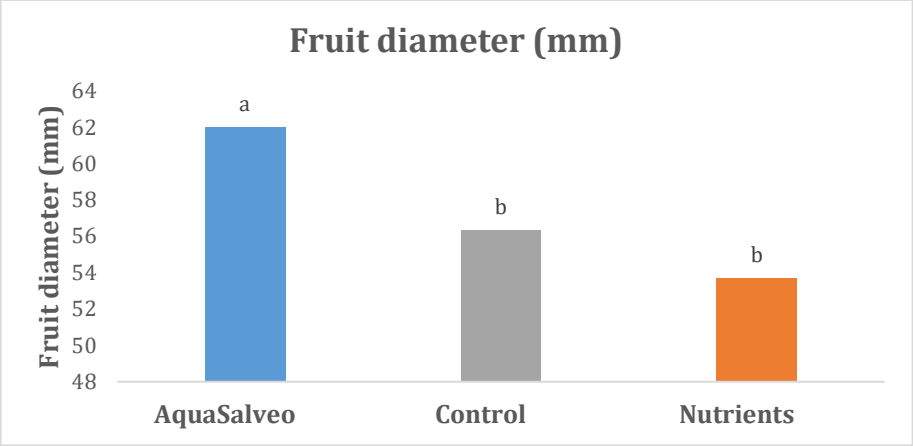


***Figure 3.** Tomato fruit diameter.*

Stem diameter

The stem diameter was similar between the Aqua Salveo Micronutrient Fertiliser treated plant and those that received nutrient solution across the different days after transplanting.

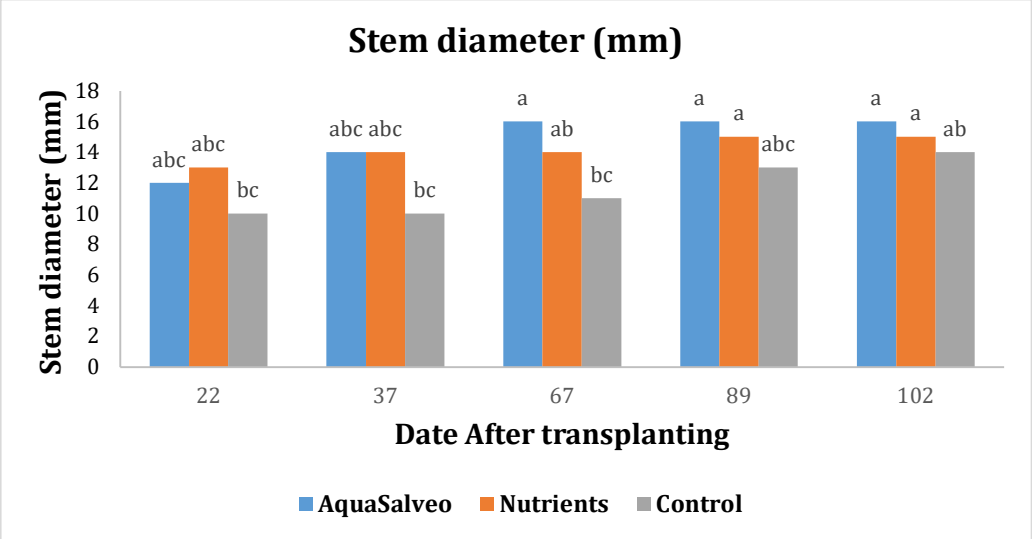


Figure 4. *Changes in stem diameter over the season.*

Plant height

The tomato height across the various treatments was fairly similar during the initial stages of growth but significant differences were observed at a later stage. At 102 days after planting, the tallest plants were those receiving Aqua Salveo Micronutrient Fertiliser followed by the nutrient solution and then the control plants.

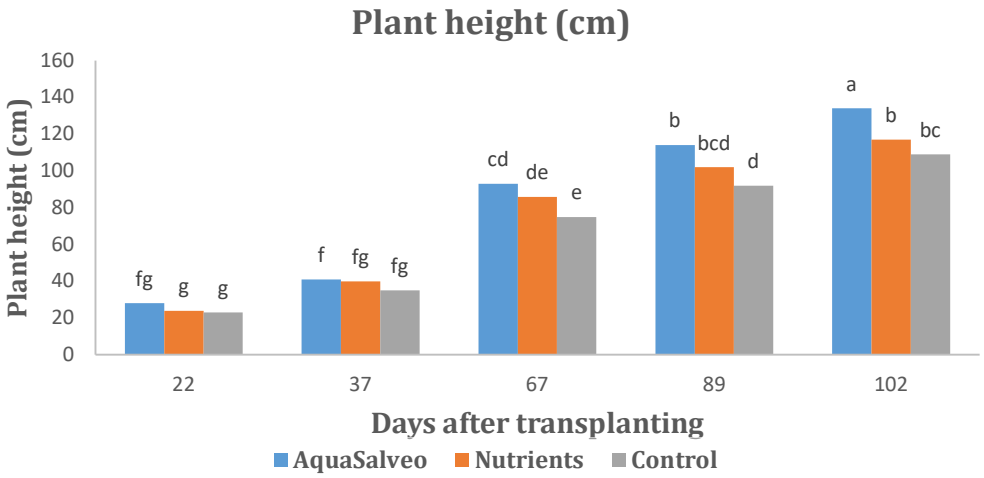


Figure 5. *Changes in Plant height over the season.*

Flowering

The application of Aqua Salveo Micronutrient Fertiliser increased the extent of flowering relative to the other treatments. At 58 days after transplanting, the Aqua Salveo Micronutrient Fertiliser treated plants recorded 60% flowering, followed by the nutrient solution which recorded 30% and then 10% in the control plants.

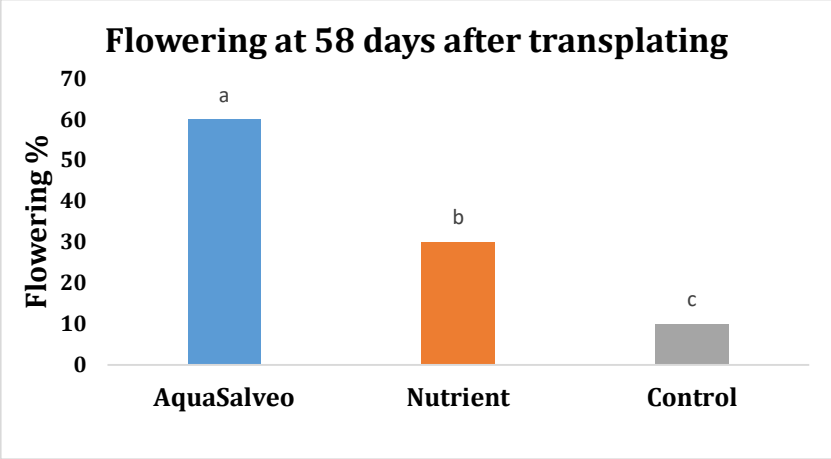


Figure 6*. The response of tomato plant to Aqua Salveo Micronutrient Fertiliser during the flowering stage.*

5.2.5 Concluding remarks

The preliminary results highlighted the growth stimulating properties of Aqua Salveo Micronutrient Fertiliser in tomatoes under both field and greenhouse conditions. The stimulating effect is expected to be enhanced when combined with adequate amounts of other plant growth nutrient ions.

5.3. TITLE: TOMATO GROWTH RESPONSE TO AQUA SALVEO MICRONUTRIENT FERTILISER CONCENTRATION RATES

5.3.1. Objectives:

Assess the impact of different dilution rates of Aqua Salveo Micronutrient Fertiliser on tomato growth
Location: Polokwane
Experimental unit: 20 cm pots.
Treatment: 4 dilution rates:

i. Control
ii. 3 drops (0.09ml) L^{-1}
iii. 6 drops (0.18ml) L^{-1}
iv. 9 drops (0.27ml) L^{-1}

Fertilization: Organic fertiliser in the form of moringa leachate and fish meal was applied uniformly to all treatments.

Fig 1. Potted tomato plants receiving different drops per litre of water at 32 days after transplanting.

5.3.2 Results

Plant height:

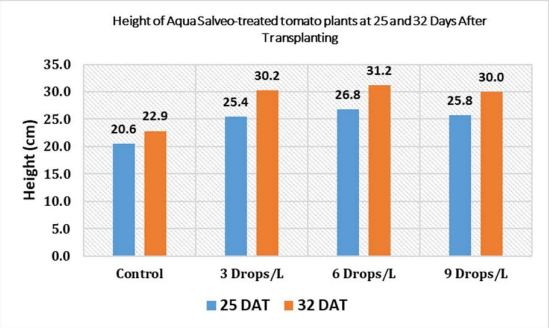


Figure 2. Aqua Salveo Micronutrient Fertiliser effect on tomato height at 25 and 32 days after transplanting.

The 6 and 9 drops resulted in taller tomato plants compared to 3 drops per litre at 25 and 32 days after transplanting.

Stem girth

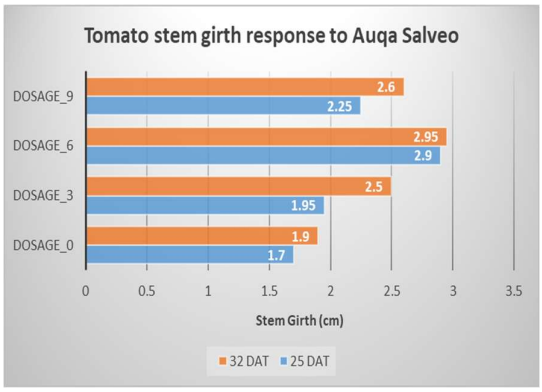
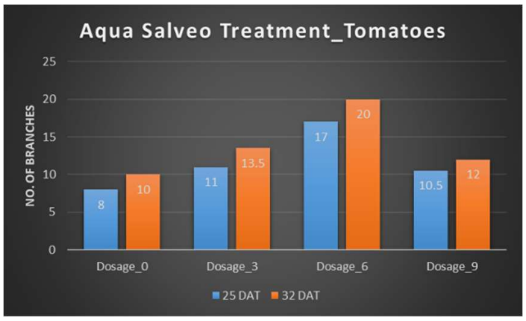


Figure 3. Aqua Salveo Micronutrient Fertiliser effect on tomato stem girth at 25 and 32 days after transplanting.

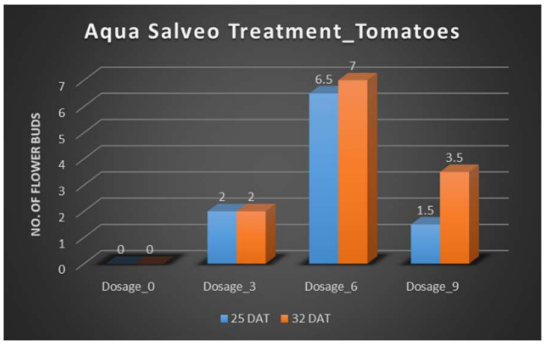
The stem girth of Aqua Salveo Micronutrient Fertiliser treated plants were enhanced at all concentrations relative to the control plants which did not receive any Aqua Salveo Micronutrient Fertiliser.

Number of branches



The highest number of branches were recorded in the 6 drops per litre treatment followed by 3 and 9 drops per litre treated plants. All treated plants produced more branches than the control plants.

Flower bud formation



TheAqua Salveo Micronutrient Fertiliser treated plants flowered earlier compared to the control plants. The highest number of buds occurred in the plants receiving 6 drops per litre at both sampling dates.

5.3.3 Concluding remarks:

The application of Aqua Salveo Micronutrient Fertiliser in the tomato plants resulted in taller plants, wider stems, more branching and early flower bud formation compared to the control plants that did not receive any Aqua Salveo Micronutrient Fertiliser.

5.4. TITLE: POTATO TUBER YIELD RESPONSE TO THE FREQUENCY OF AQUA SALVEO MICRONUTRIENT FERTILISER UNDER HIGH FERTILE SOIL

5.4.1. Introduction and rational

Potot requires a high nutrient application to establish satisfactory yields partly due to the crop's poor root system. Farmers, therefore, tends to over inorganic fertilizer with the hope of meeting the crops need. This practice is not only costly but causes severe environmental and health issues through leaching and runoff of unused nutrients.

5.4.2. Objectives

To evaluate the effect of nano zinc and copper at different application frequencies on potato tuber yield and under high nutrient soil.

5.4.3. Treatments

Five treatments were studied.

	Treatment
1	Aqua Salveo applied 3 times a week
2	Aqua Salveo applied once a week
3	Aqua Salveo applied once in two weeks
4	Aqua Salveo applied once a month
5	No Aqua Salveo

5.4.4. Results

Results from the trial, revealed a potato yield ranged from approximately 39 to 46 tons per hectare.

Numerically, the highest potato tuber yields were recorded under the application frequency of 3 times a week and once a week (Fig.).

The yield from the more frequent application was 27.84% higher than the tuber yield from the unfertilised plots under this high fertile soil.

5.4.5. Concluding Remarks

- Potato yield was increased in response to aqua salveo micronutrient application
- More frequent application of the micronutrient tended to increase potato tuber yield.
- More studies are required to establish the full biological and economic benefits of aqua salveo micronutrient in potato production.

6. OVERALL REMARKS

Nanotechnology seems to have a promising potential to contribute significantly to more sustainable Agriculture in the future. The application of Aqua Salveo micronutrient fertiliser in tomato production significantly enhanced plant growth parameters, fruit yield and fruit size. Aqua Salveo Micronutrient Fertiliser also significantly reduced *Fusarium* and *Verticillium* wilt in infected tomato plants.

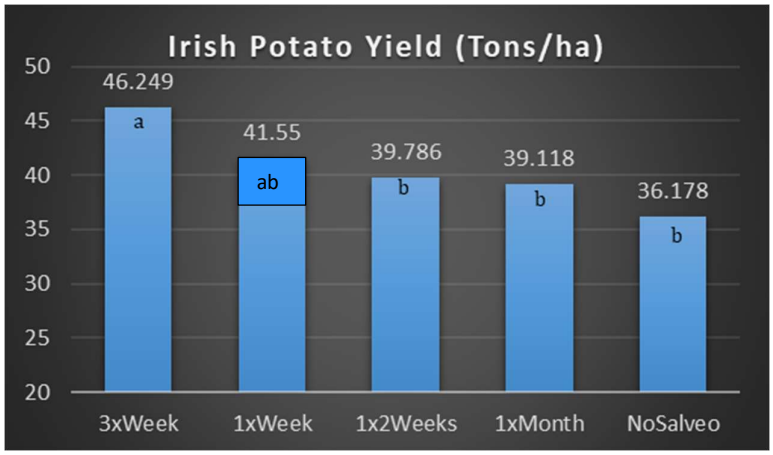


Fig. Potato tuber yield.

Potato harvest from the field.

7.0 FIELD OBSERVATIONS

The following observations have been reported by farmers and other users of Aqua Salveo Micronutrient Fertiliser applications.

	A **wil**d pawpaw tree irrigated with Aqua Salveo Micronutrient Fertiliser in Kumasi, Ghana. Impact: • Instant stimulation of flowers • Improve fruit set • Expanded leaf and leaf stalk • Significantly reduced leaf drop

	Cabbage irrigated with Aqua Salveo Micronutrient Fertiliser Micronutrient Fertiliser and organic manure in a plastic tunnel greenhouse in Mokopane, South Africa
	Pettie Belle pepper (*Capsicum chinense*). This crop received Aqua Salveo and moringa leachate as organic fertiliser, resulting in high fruit production on a small-structured plant. This translates to a high harvest index (The ratio of fruit yield to total aboveground biomass yield)
 	A young plantain seedling (*left photo*) following the application of Aqua Salveo micronutrient fertiliser and moringa in a semi-arid environment of northern south Africa. The plant received minimum temperature of 15^{o}C and above for approximately six weeks and produced a sucker (*right photo*).

Pomegranate fruit treated with Aqua Salveo micronutrient fertiliser and moringa leachate.