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Comparison of Chelated Calcium with Nano Calcium on Alleviation of Salinity Negative Effects on Tomato Plants.

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ABSTRACT

This work was designed to investigate the alleviation of salinity negative effects by application of calcium in two different forms to tomato plants hybrid Super strain B irrigated with saline water with an EC 5.47 dS/m. Chelated calcium (CaO-EDTA 14%) or nano calcium (nano calcium carbonate 80.2%) forms were applied to the plants through drip irrigation system in two concentrations (2.0 & 3.0 g/l and 0.5 & 1.0 g/l for CaO-EDTA and Nano Ca respectively). Salinity showed the common negative effects on different plant growth parameters and yield. However both Ca compounds treatments alleviated those negative effects with a superior significant effect for nano calcium treatment of 0.5 g/l compared to all other treatments. Plant fruit yield and nutritional status were significantly improved under nano calcium treatments with superior effect of 0.5 g/l concentration.

Key words: Tomato, salinity, nano calcium; growth, yield

Introduction

Fertilizers are important factors in agriculture since they provide essential nutrients for plant growth and development. Science has identified all necessary nutrients for plants however the current mission of scientific research is to deliver such nutrients to the plants in the most efficient way. The use of the new science, nanotechnology in agriculture has begun and will continue to have a significant effect in the main areas of breeding new crop varieties, development of new functional materials and smart delivery systems for agrochemicals like herbicides, fertilizers and pesticides, smart systems integration for food processing, packaging and other areas like remediation of herbicide and pesticide residues from plant and soil, effluent water treatment, etc. (Moraru *et al.,* 2003). The term 'nanotechnology' encompasses a wider range of activities. 'Nano' is used in the world of science to mean one billionth. A nanometer is a billionth of a meter. A nanometer is only ten atoms across. Generally nanotechnology is used to mean technology at the nanometer level to achieve something useful through the manipulation. Nano-technology can present solution to increasing the value of agricultural products and environmental problems. With using of nano-particles and nano-powders, we can produce controlled or delayed releasing fertilizers. Nano-particles have high reactivity because of more specific surface area, more density of reactive areas, or increased reactivity of these areas on the particle surfaces. These features simplify the absorption of fertilizers and pesticides that produced in nano scale (Anonymous, 2009). There are a few reviews about the effects of nano-particles on plants. Studies showed that the effect of nano-particles on plants can be beneficial (seedling growth and development) or non-beneficial (to prevent root growth) (Zhu *et al*, 2008).

Calcium is one of the main macro essential nutrients for plant growth. In addition for being essential in building cell walls of the plant, it plays an important role in enabling the plant to tolerate saline conditions. Salinity has many negative effects on plant growth and production (Abdel-Mawgoud *et al.,* 2004; 2010; El-Abd et al, 2005; Tantawy *et al.,* 2009; 2013) due to its negative osmotic effects and/or to specific ion effects of some ions in the root zone such as sodium. Most plant physiologists believe that the deleterious effects of Na+ may be elevated by increasing the Ca^{2+} external concentration (Tuna *et al.,* 2007). Also, Rengel (1992) suggested that increasing calcium in external concentration may have ameliorative effect on NaCl stressed plants. This amelioration has been attributed to transport and discrimination of salts (Subbarao *et al.,* 1990) and to improved osmotic adjustment due to accumulation of osmoregulators in the root system as a result of the interaction between Na+ and Ca^{2+} (Colmer *et al.,* 1996). Also it has role in reducing Na+ uptake and increasing K+ and Ca^{2+} uptake, resulting in an increase in plant growth (Rengel ,1992) or by decreasing Na+ influx through nonselective cation channels (Shabala *et al.,* 2006).

For these reasons, this work aimed at investigating the effect of calcium fertilizers in two forms, chelated or nano forms, in alleviating the negative effects of salinity on tomato crop.

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Materials and Methods

Tomato (*Lycopersicon esculentum* L.) seedlings Super strain B hybrid, identified as salinity sensitive cultivar ((Malash *et al.*, 2002), were transplanted on March 10th in the two seasons of 2013 and 2014 in a sandy soil in a private farm in the area of Wadi El-Natron, Bahaira governorate, Egypt. The soil physical and chemical analysis are shown in tables 1 and 2. Individual transplants were grown at the bottom of ridges 100 cm width at 40 cm apart. Plot area was 1X12= 12 m^2. The drip irrigation system of GR 16 was used and plants were irrigated daily using saline-well water with an EC value 5.47 dS/m and pH of 7.8. The complete chemical analysis of the irrigation water is shown in table (3).

All standard agricultural practices other than experimental treatments were applied according to the recommendations of the ministry of agriculture, Egypt.

Experimental treatments:

After three weeks from transplanting, plants were supplied through the irrigation system with two types of calcium forms namely chelated Ca (CaO-EDTA 14%) or Nano-Ca (nano Calcium carbonate 80.2%). Each form was supplied to the plants in two concentrations in addition to the control treatment as follow:Nano-CaCO3: 0.0 (control); 0.5 or 1.0 g/l. Meanwhile CaO-EDTA 14% was applied as 0.0 (control); 2.0 or 3.0 g/l.

Nano-CaCO3 was manufactured by the use of the mineral Dolomite which consists of Calcium or Magnesium carbonate. Dolomite was milled in Hitec-Nano-millsat 20,000 rpm to extremely fine powder (commercially named LITHOVIT). During the milling process the particles are highly activated by means of tribodynamic activation which enables the CO2 to release in the intercellular compartment as well as right at the leaf surface. In addition the high input energy in the milling process activates the surface of the particles with an electrical charge which increase the activity of those particles.

Applications of calcium treatments were at 3, 6, 9 and 12 weeks after transplanting.

Experimental design and statistical analysis:

The treatments were arranged in a complete randomized block design with three replicates and analysis of variance was carried out at probability level of 0.05. Least Significant Difference LSD was calculated to differentiate between the treatments.

Measurements:

After 70 days from transplanting the following measurements were carried out:
Physical measurements: Plant height, number of branches, fresh and dry weights of areal parts; total yield; and total number of harvested fruits.
Chemical measurements: Total chlorophyll content (SPAD); total soluble solids (TSS) of harvested fruits; Ca and Na contents.

Table 1. Soil physical analysis and soil properties of the experimental farm.

Soil depth (cm)	Total sand (%)	Silt (%)	Clay (%)	Texture
0-15	58.0	11.5	30.5	Sandy
15-30	57.0	13.0	30.0	Sandy

Table 2. Soil chemical analysis of the experimental farm.

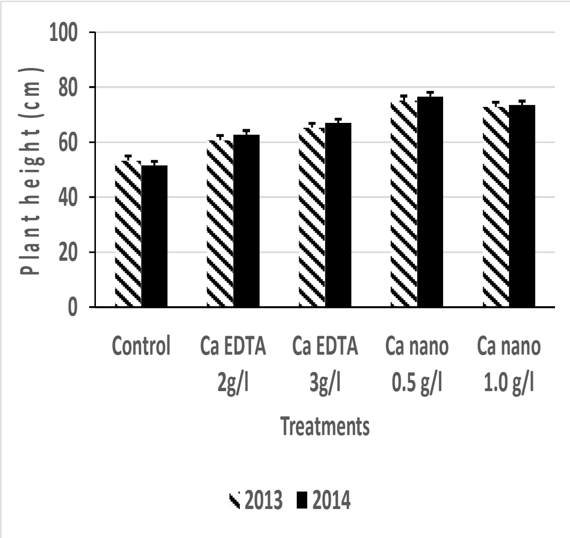
Soil depth (cm)	EC (dS/m)	pH	Soluble anions (ppm)			Soluble cations (ppm)			
			$CO3^{--}$	Cl^{-}	$SO4^{--}$	Ca^{++}	Mg^{++}	Na^{+}	K^{+}
0-30	4.77	7.7	55.85	31.20	10.50	24	11	10.52	2.18
30-60	4.16	7.4	51.21	22.50	16.10	16.83	6	17.80	0.097

Table 3. Chemical analysis of irrigation water (underground well) of the experimental farm.

Water sample	EC (dS/m)	pH	Soluble anions (ppm)			Soluble cations (ppm)			
			HCO3-	Cl^{-}	$SO4^{--}$	Ca^{++}	Mg^{++}	Na^{+}	K^{+}
Average	5.47	7.8	2.50	81.08	16.24	25.29	19.43	54.83	0.45

Results

Plant height and number of branches (Fig. 1) showed similar and positive responses to all calcium application treatments compared to control. While the response increased as the chelated calcium concentration increased, the low concentration (0.5 g/l) of nano-calcium application showed higher response compared to the highest applied concentration (1 g/l). All differences were significantly higher than the control treatment all treatments were significantly different among each other.



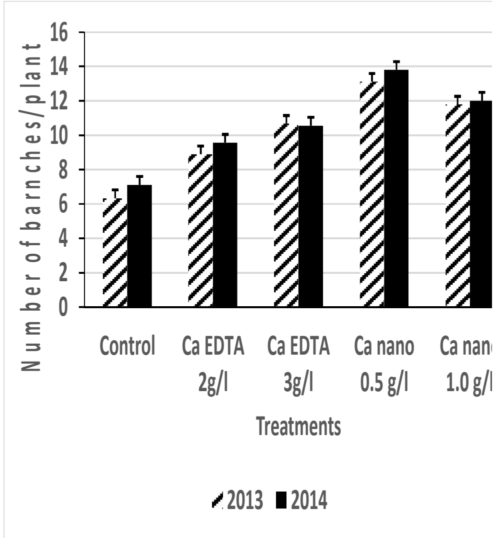


Fig. 1. Plant height (left) and number of branches (right) of tomato plants fertilized with different concentrations of chelated Ca or nano-Ca during the two growing seasons of 2013 and 2014. Error bars are LSD 5%.

Chlorophyll content (Fig. 2) showed also a positive response to all calcium application treatments. The highest response was recorded with the nono calcium application of 0.5 g/l followed by the same application at 1.0 g/l then the chelated calcium at 3 and 2 g/l respectively. All calcium treatments were significantly higher than control and all treatments were significantly different among each other.

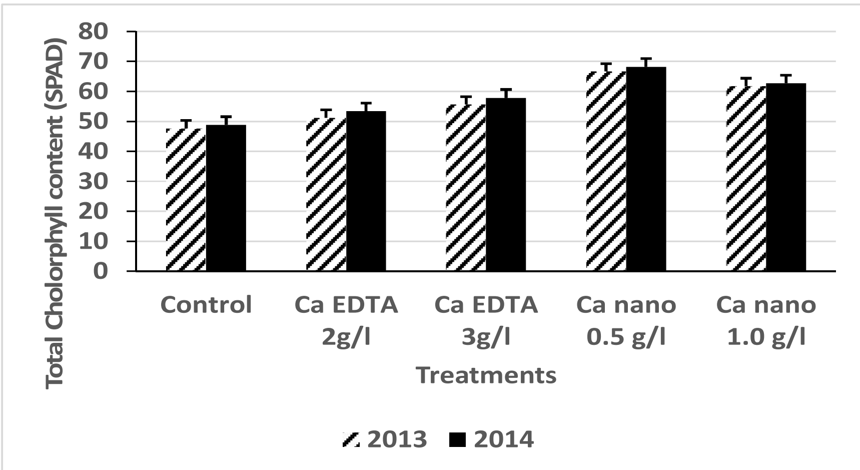


Fig. 2. Total chlorophyll content of tomato plants fertilized with different concentrations of chelated Ca or nano-Ca during the two growing seasons of 2013 and 2014. Error bars are LSD 5%.

Differences among treatments were clearer in the fresh and dry weights of the plant areal parts (Fig. 3). Nano calcium application at 0.5 g/l was superior in its effect on both parameters compared to all other treatments including the control. All differences were positive and significant compared to control. Generally nano calcium treatments were significantly higher than chelated calcium treatments. However, both treatments showed opposite trends in terms of effect of applied concentrations. While lower concentration of nano calcium (0.5 g/l) showed the highest effect, higher concentration of applied chelated calcium (3.0 g/l) showed higher effect compared to the lower concentration of the same compound (2.0 g/l).

The above positive responses reflected on fruit yield (weight and number) where it showed the same previously observed trend (Fig. 4). Nano calcium treatments had higher positive effects on those parameters compared to chelated calcium treatments. While the lower concentration of nano calcium recorded the highest positive effect on the concerned parameters, the highest chelated calcium concentration showed higher response compared to the lower concentration. All calcium treatments were significantly higher compared to control.

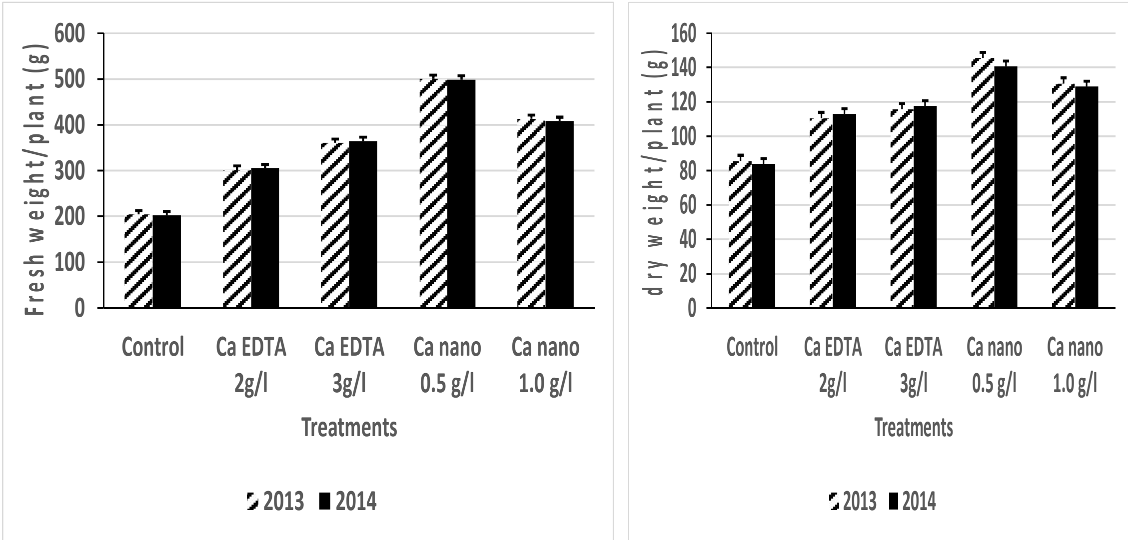


Fig. 3. Areal parts fresh (left) and dry (right) weights of tomato plants fertilized with different concentrations of chelated Ca or nano-Ca during the two growing seasons of 2013 and 2014. Error bars are LSD 5%.

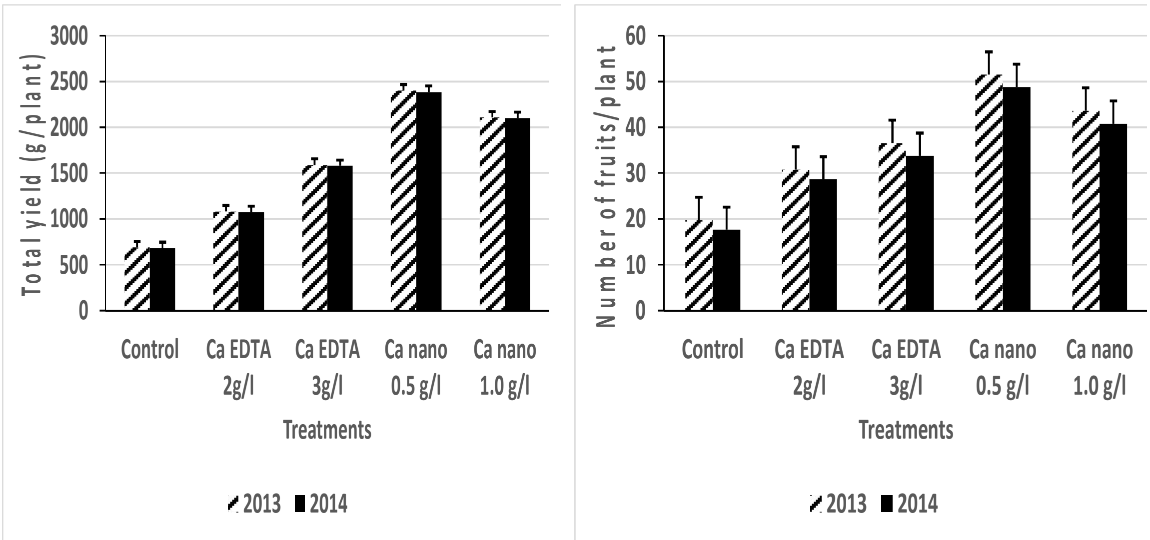


Fig. 4. Total weight (left) and number (right) of tomato fruits harvested from tomato plants fertilized with different concentrations of chelated Ca or nano-Ca during the two growing seasons of 2013 and 2014. Error bars are LSD 5%.

Calcium content showed similar trend where the application of all calcium treatments increased calcium content significantly in the fruits (Fig. 6). Nano calcium applications showed higher significant effect than chelated calcium treatments. The lower concentration of nano calcium application was superior compared to all treatments.

On the other hand, sodium showed a completely opposite trend compared to all previous observed trends (Fig. 6). Nano calcium treatments showed the lowest significant contents of sodium in the fruits compared to control meanwhile, the highest sodium content other than the control was recorder with the application of chelated calcium at concentration of 2.0 g/l.

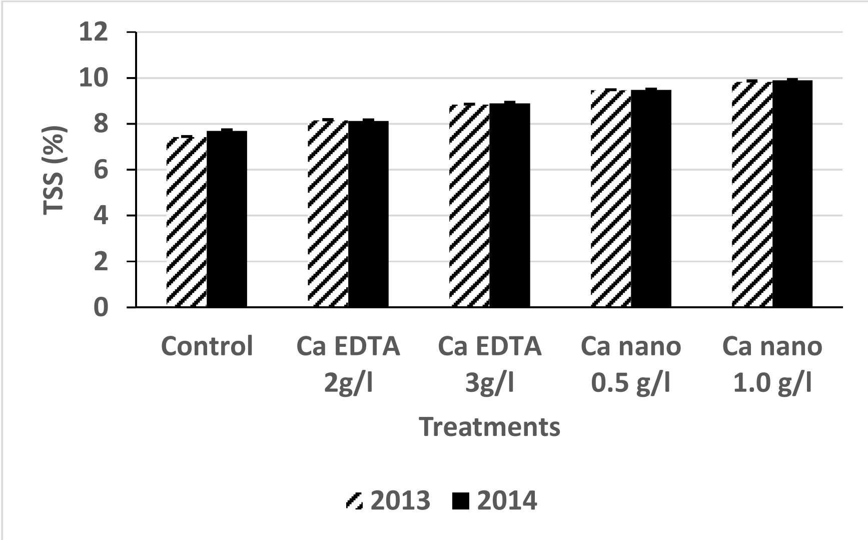


Fig. 5. Total Soluble Solids (TSS) of tomato fruits of plants fertilized with different concentrations of chelated Ca or nano-Ca during the two growing seasons of 2013 and 2014. Error bars are LSD 5%.

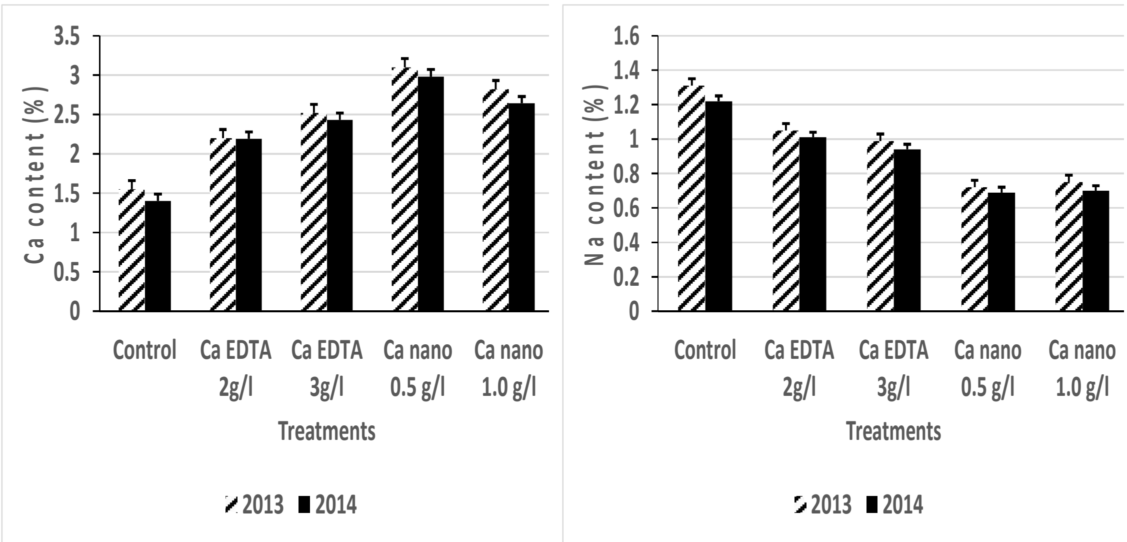


Fig. 6. Total calcium (left) and sodium (right) contents of tomato plants fertilized with different concentrations of chelated Ca or nano-Ca during the two growing seasons of 2013 and 2014. Error bars are LSD 5%.

Discussion:

Salinity has ever known to have negative effects on plant growth and production (Abdel-Mawgoud *et.al*, 2004; Tantawy *et.al.,* 2009 and Hegazi *et.al*, 2014). Many trails have been made to overcome or alleviate those negative effects (Abdel-Mawgoud, 2002; Abdel-Mawgoud *et.al.*, 2004; 2005; Tantawy *et.al.*, 2009). Among those trails is the application of some nutrients such as calcium to counteract the specific effects of some ions such as sodium (Rengel, 1992; Colmer *et.al*, 1996; Tuna *et.al*, 2007). In this study, the improving effects of calcium were confirmed. It was the aim to improve such alleviating function of calcium by providing it to the plants in different forms and concentrations. Our results cleared that the calcium in the nano forms was superior in its effects compared to the chelated forms. Very rare literature were found about using nano calcium for improving plant growth and production (Liu *et.al.*, 2005). The latter found that supplying peanut plants with calcium carbonate in the nano form improved number of branches and fresh and dry weights of the plants. These confirm our results of this study where obvious improvements in plant fresh and dry weights as well as number of branches were recorded. These improvements may be resulted from improvements in the physiological process of the plants such as photosynthesis as the chlorophyll contents of tomato plants increased under treatments of nano calcium. This is confirmed by the findings of Liu *et.al*., (2005) who found higher soluble sugars and proteins of the areal parts of the plants under nano calcium treatment. As was observed in our study, Liu *et.al*., (2005) observed an improvement in the absorption of nutritional elements in the contents in the shoots. The improvements in the contents of soluble sugars, proteins and nutritional elements may explain the high contents of the total soluble solids recorded in the tomato fruits measured in this study.

All these superior effects of nano calcium may be brought about by increasing the surface area of the calcium carbonate which increase its activity and improve its effects.

It can be concluded that the effect of calcium in counteracting the negative effects of salinity can be improved by supplying the calcium in the nano form.

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