Vali-e-Asr University of Rafsanjan

Research Project Report

Evaluation of TKInt fertilizers application on Pistachio yield and quality, KTS and CaTs evaluation on Pistachio in saline soil

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Part I. Overview of pistachio culture in Rafsanjan

Introduction

Rafsanjan is a city and capital of Rafsanjan County, Kerman Province, Iran. It is located in south part of the Lut desert, in north-west of Kerman province. The longitude of this city is 56 degrees east and the latitude is 30 degrees south (Fig. 1). Rafsanjan has two seasonal rivers named as Shour and Giouderi. The mountains in the area are part of Zagros range, and Sarcheshmeh and Davaran are the most famous. It is one of the most important and crowded cities of Kerman and has an undeniable role in the economy of state and country. Mines and pistachios in this city are well known not only in Iran, but all around the world. It is a major center of pistachio cultivation and also the biggest area of producer of pistachios in the world (Darijani et al., 2019).

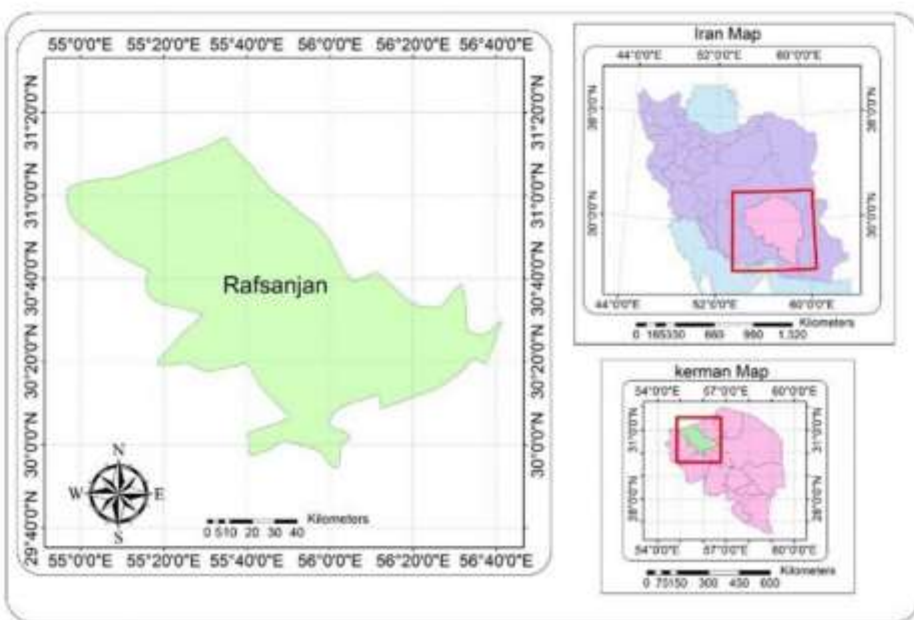

Figure 1- Study area map

Rafsanjan has cold and freezing winters as well as hot and dried summers. This city is located in the central part of Iran and this region is desert. The weather is hot in summer and cold in winter, days are warm and nights are cold in general. The average amount of rainfall is about 100 mm (3.9 in) annually.

Pistachio production and commercial cultivars

Iran exports 150,000 to 200,000 tons of pistachios annually. This is while the global demand for Iranian pistachios can even reach a few million tons. Presently Iran accounts for more than 50 percent of global pistachio production. Currently, pistachios grow in over 360,000 hectares of land in Iran and Kerman province procures 77 percent of the country's pistachio needs (Darijani et al., 2019). The province is essentially viewed as the most important region in the world for growing pistachios. Other areas of the country wherein pistachios are grown include Yazd, Khorasan, Fars, Semnan, Sistan and Baluchestan, Qazvin, Isfahan and Qom. The total production of Iranian pistachios is more than 220,000 tons with an average yield of 1100 kg per hectare in the "On" year and about 800 kg per hectare in the "Off" year. Of course, in recent years, with the improvement of horticultural operations, the yield average has increased significantly (IPA).

Iranian pistachios include many local names and each name represents a region shape or quality type. The most famous and commercial cultivars of Iranian pistachio are as the following items:

1. **Akbari:** This type is the highest economic value. Its fruits are large and almond shaped. It can be harvested in late September. This is a newer variety with good yield and with long, large nuts (Fig. 2).

Figure 2- Akbari cultivar

2. **Kaleh Qouchi:** This nut is famous for being large. It is sensitive to shortage of water and its leaves are complex. This type of nut is vulnerable to cold weather in spring. It can be harvested in mid-September (Fig. 3).

Figure 3- *Kaleh Qouchi cultivar*

3. Ahmad Aghaei: This nut is rather large and its fruit is almond shaped. It can be harvested in late September. The newest commercial variety, very popular with the farmers, because of high yield and its shorter time to reach production. It is very popular in some markets like India and Greece. Production of this variety is increasing. It also has the whitest shell hue among the four (Fig. 4).

Figure 4- *Ahmadaghaei cultivar*

4. Fandoghi (Ohadi): This cultivar is the most widely available pistachio variety and grows in most pistachio growing areas of Iran. Fandoghi is of round type and has the lowest shape index among the four cultivars. In recent years, around 50% of Iranian production is of the Fandoghi type. The reason is its limited yield; the new orchards are seldom planted with this cultivar (Fig. 5).

Figure 5- Fandoghi cultivar

Pistachio tree generally prefers dry climate with very low humidity. In humid climate, pistachio will not produce but will grow. Ideal weather conditions for pistachio tree are hot and dry climate in summer (not too hot) with cold and temperate winters (IPA).

Pistachio irrigation

In general, the water resources considered for pistachio orchard must be long-lasting (at least 50 years). The amount, frequency and method of irrigation greatly affect pistachio production. The cultivation of young trees, the prevalence of pests and diseases that attack the tree through the air or soil, the quantity and quality of the biennial crop and the growth of the tree are all affected by the irrigation of the pistachio tree. In addition, climatic conditions, soil and root texture and pistachio tree transplantation are among the important factors that affect the amount of water required to produce an economic crop. Assuming the lowest water losses in water transfer and garden irrigation, each hectare of mature pistachio orchard requires 12,000 m^3 of water per year. The above water requirement excludes the water required for winter leaching of saline soils. If salinity is present in the topsoil or root zone, one to two winter leaching should be added to the required natural water regime.

The water requirement of pistachio tree is varied in different seasons of the year and different stages of its annual life cycle. This irrigation regime is lowest in the winter and is highest in the summer, when pistachio kernels are growing. Most of the water required annually is used by the tree in summer (July, August and September). Irrigation is the most important operation during the season. Drought stress causes leaf shriveling and eventually drying and fall, then the photosynthetic level of the plant decreases and there is not enough leaves on the tree intensifying the effects of sunburn on the branches and finally complete drying of the plant. Severe and longterm stresses lead to the cracked bark of the tree and it easily separated from the trunk (IPA).

The problems of pistachio cultivation in Rafsanjan

Pistachio can withstand low temperatures to -20^{o}C in winters and easily tolerates up to 42^{o}C in summer and gives a good product. Of course, the resistance of this plant to natural disasters is more than this, but we mentioned the conditions that can harvest a good crop without any problems, depending on the age and type of tree. The most important challenge of pistachio is early chilling of spring or early warm weather in April when the flower induction will happen. In 2017, due to early spring heat, most of the reproductive buds did not formed in pistachio-growing areas of Kerman province.

Another problems faced by pistachio growers today are the lack of enough water and also soil salinity. The increase of new pistachio orchard in recent decades and the decrease in the groundwater level have caused the lack of enough water for the growth and production of pistachios; therefore, the producers have several problems with solutes accumulation such as sodium and chlorine in the soil, which greatly affects the growth and production of pistachios.

Also, the lack of temperature between 2-7 ^{o}C for bud break of some cultivars such as ‘Ohadi’ and ‘Akbari’ is another problem of pistachio production in Rafsanjan region (IPA).

Soil Salinity

Salinity is one of the most important problems that restrict cultivation of crops in arid and semi-arid regions. Although it was indicated that pistachios tree may tolerate soil salinity, but it affect the total yield and other parameters of pistachio tree. Soil salinity is an index of the concentration of salts in soil and is usually expressed as electrical conductivity (EC). The saltaffected soils contain excessive concentrations of either soluble salts or exchangeable sodium or both due to inadequate leaching of base forming cations. The major soluble mineral salts are the cations: sodium (Na^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+) and the anions: chloride ($Cl^−$), sulfate ($SO_2{}^{−4}$), bicarbonate ($HCO^{−3}$), carbonate ($CO_3{}^{−2}$), and nitrate ($NO_3{}^−$). Hyper-saline soil water may also contain boron (B), selenium (Se), strontium (Sr), lithium (Li), silica (Si), rubidium (Rb), fluorine (F), molybdenum (Mo), manganese (Mn), barium (Ba), and aluminum (Al), some of which can be toxic to plants and animals (Horneck et al., 2007).

Characteristics of salt-affected soils

The salt-affected soils are classified into three groups depending on the nature and concentration of salts present in them:

i. Saline soils (also called "white alkali" or "solonchak" soils): soils containing calcium, magnesium, and sodium as predominant exchangeable cations (Ca and Mg more than Na), and sulfate, chloride, and nitrate the predominant anions; sodium adsorption ratio (SAR) <13; exchangeable sodium percentage (ESP) <15 of total CEC; pH <8.5; EC of saturation extract >4 dS $m^{−1}$; white color due to white crust of salts on the surface; good permeability for water and air; salt problems in general; the salt concentration is enough to adversely affect the growth of most crop plants; mostly found in arid or semi-arid regions where less rainfall and high evaporation rates tend to concentrate the salts in soils; rarely found in humid regions.

ii. Sodic soils (also called "non-saline sodic soils" or "alkali soils," or "solonetz"): soils high in exchangeable sodium compared to calcium and magnesium; sodium carbonate and sodium bicarbonate are the predominant salts; SAR >13; ESP >15; pH = 8.5–10.0; EC of saturation extract

<4 dS m−1; black color; poor permeability for water and air; soils formed due to exchange of Ca2+ and Mg2+ ions by Na+ ions; sodium problems.

iii. Saline-sodic soils: these soils are transitional between saline and sodic soils; SAR >13, ESP >15, pH >8.5; EC of saturation extract >4 dS m−1; air and water permeability depends on the sodium content; soils formed due to combined processes of salinization and alkalization; problems with sodium and other salts; leaching converts these soils into sodic soils.

Before using different fertilizers, pistachio orchards need soil reclamation. Soil reclamation is usually done in winter and mostly in saline, alkaline and heavy. The best material is gypsum and it should be used on the surface of soil and mixed well. It should be remembered that never use it in the fertilizer channel where there is phosphorus fertilizers. In case of contact with phosphate fertilizers such as triple superphosphate, it will turn it into insoluble or insoluble salts. Nowadays, the growers use gypsum and to solve the problem of salinity in the soil. The amount of applied gypsum in the soil will reach up to 40 tons per hectare depending on the quality of the gypsum and salinity in the soil. Gypsum has many applications in soil. Important roles of gypsum include reducing salinity, reducing the absorption ratio of sodium, increasing the ratio of calcium to magnesium, and in the long run can also affect the pH.

Calcium is required for sodic soil reclamation, as it will displace sodium and reduce the exchangeable sodium percentage (ESP) and SAR (Fig. 6). If possible, use irrigation water that is high in calcium during the initial phase of reclamation. Gypsum (calcium sulfate) is the most common material used to supply calcium for sodic soil reclamation (Horneck et al., 2007).

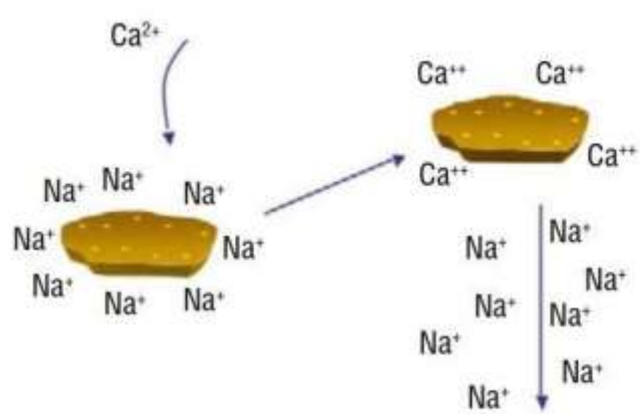

Figure 6- Apply a source of calcium (such as gypsum) before leaching salts out of soils susceptible to the dispersion. Replacing sodium with calcium before leaching will stabilize soil structure.

Gypsum is used because it is calcium-rich, dissolves at high pH, and does not contain elements or compounds that might interfere with reclamation. The sulfate in gypsum is not likely to be a problem for crops, even though it is applied in quantities greatly in excess of plant need. Calcium nitrate or calcium chloride minerals can be used to reclaim sodic soils, but they generally are more costly and are likely to produce other negative effects on plant growth or the environment. Nitrate is considered a groundwater contaminant and is not a good choice.

The use of sulfuric acid (H_2SO_4), depending on the salinity of the soil, is between 200 and 400 liters per hectare in winter, although at other times, except during the warm months, such as late June and August, they use the acid in irrigation between 50 and 70 liters per hectare. The use of sulfuric acid has increased sharply in the last three years in Rafsanjan. Of course, there are cases in which the farmer has been used sulfuric acid up to 1500 liters per hectare.

Applying the sulfuric acid as fertigation could consider another procedure to save the plants from harmful effects of salts. The acid can be applied at the time of soil preparation. This acid provides native calcium present in the soil available (Fig. 7). In others words the acid makes gypsum available. By lowering the pH of soil, micronutrients become available to crop. It improves soil environment by reducing impact of salinity and high pH. Reduce soil compactness and enhance soil porosity by replacing sodium of soil with calcium (Horneck et al., 2007).

$$H_2SO_4 + \underset{(Lime)}{CaCO_3} + H_2O \Longrightarrow CaSO_4.2H_2O + \overset{(gas)}{CO_2}$$

$$\overset{(Na^+)}{\text{Soil Colloid}} + CaSO_4 \Longrightarrow \overset{(Ca^{+2})}{\text{Soil Colloid}} + Na_2SO_4 \text{ (Leach down out of root zone).}$$

Figure 7- The conversion of lime to gypsum by using sulfuric acid (H_2SO_4)

Pistachio is characterized by alternate bearing, with yield varying widely between on- and off-years. Alternate bearing strongly influences K uptake and distribution in pistachio trees. Nonetheless, current fertilization practices in the pistachio orchard have largely ignored the impacts of crop load on tree nutrient demands and capacity for nutrient uptake from the soil. K deficiency has affected the productivity of pistachio trees in many orchards. The causes for K deficiency are primarily: 1) limited use of K fertilizers; 2) increased yield, which removes more K from the soil 3) strong soil K fixation, reducing soil K availability; and 4) excessive use of N fertilizers, particularly ammonium-N that tends to acidify the soil and inhibit K uptake. If K fertilizers are not adequately applied to replenish the soil K pools, K deficiency will increase in severity and extent in pistachio (Holtz, 2001).

This project examined the benefits of CaTS and KTS soil application in drip irrigation on the yield and quality of pistachio in Rafsanjan orchard.

Part II. Research design and the methods of fertilizer application

Location and plant materials for the experiment:

The experiment was conducted during March to September of 2020. The pistachio orchard was located in Javadiyeh Fallah area which is located 80 km far from Rafsanjan (Fig. 8).

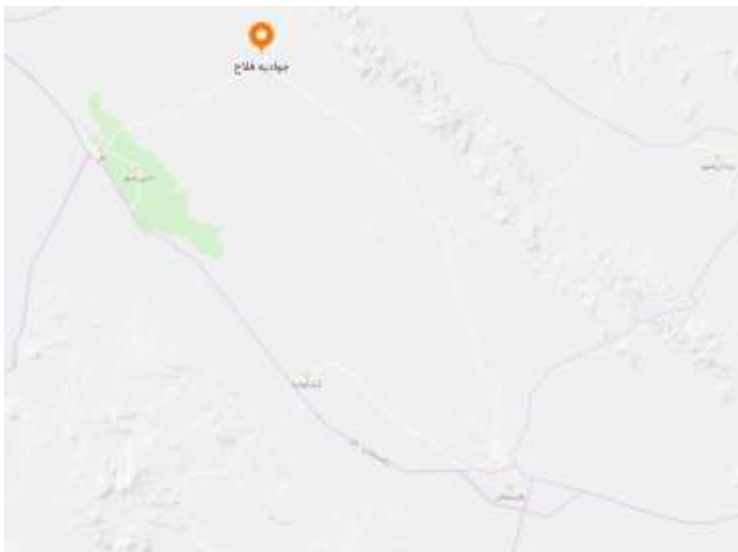

Figure 8- The location of pistachio orchard for the project

The 14-year-old pistachio trees cv. Ahmadaghaei were spaced 4 meters apart on a row and 6 meters between rows (Fig. 9). The situation of tree orchard and site of experiment was studied before fertilizer application. The soil samples were prepared in different parts of the orchard and analyzed (Fig. 10).

Figure 9- The site of plant materials for the experiment

Figure 10- The soil sampling for soil analysis before experiment

The trees in experiment site were irrigated using a drip irrigation system (Fig. 11) and irrigation period was every 30 days on March–April and every 15 to 20 days on June-September.

Figure 11- Drip irrigation system in the experiment site.

The plot size was considered about 3100 m^2 and divided into 4 blocks. 4 following treatments were performed to be done in each block:

1. Control (grower practices).
2. KTS (T1+ 100 liter/ha KTS: 40% in May, 40% In June, 20% in July).
3. CaTs (T1+ 2 soil application of 50 liter/ha /application CaTs at three week before bud break and at flower set and 2 soil application of 25 liter/ha /application CaTs every month).
4. KTS and CaTs (100 liter KTS and 150 liter CaTs : the same as treatment 2 and 3).

Each block contains 4 treatments (1 to 4) and each treatment consists of 8 trees. 32 trees in each block and 128 trees in total in a completely randomized block design replicated 4 times.

Depending up on the irrigation regime which was varied by the orchard manager because of air temperature, relative humidity and etc., the treatments were applied on exact time during experiment (Table 1).

Table 1- The time of fertilizer application and soil and leaf sampling date

Treatments	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Time of application (cc/tree)	C ontrol (grower practices)	KTS (cc/tree)	CaTs (cc/tree)	KTS+CaTs
March 27	-	-	125	CaTs: 125
April 30	-	-	125	CaTs: 125
May 29	-	100	60	CaTs: 60 & KTS: 100
June 6	Soil Analysis	Soil Analysis	Soil Analysis	Soil Analysis
July 1	-	100	60	CaTs: 60 & KTS: 100
August 5	-	50	-	KTS: 50
August 5	Leaf Analysis	Leaf Analysis	Leaf Analysis	Leaf Analysis

All treatments were applied through drip irrigation. To do the treatments in drip system, first the irrigation was performed for 6 hours and in the water pond that was created under the dropper, a certain amount of solution was poured, after which the irrigation was continued for 8 more hours.

The grower practices used for the control tree consist of: In winter, rotten cow manure is used. Also, the required micro elements such as Fe, Zn, B and etc. and also some macro elements such as P, N and K was applied among cow manure. From March to April, 50 kg/ha of calcium nitrate was used. Also 50 kg/ha of phosphate was used twice during the growing season, 50 kg/ha of ammonium sulfate was used. Iron fertilizer and sulfuric acid (20 l/ha) were also used in each irrigation water times during growth season except during warm months of the year (July and August), the potassium was applied in the form of Solupotasse four times, 125 kg per hectare in total.

Also, it should be mentioned that 300-400 l/ha of sulfuric acid was used in winter for Soil reclamation followed by heavy irrigation. It Should be noted that all grower practices were applied both in control and other treatments (KTS, CaTs and KTS+CaTs).

At harvest, the following parameters were evaluated: Total yield, dried yield, pistachio dehiscence (%), pistachio indehiscence (%), pistachio blankness (%) and pistachio Ounce.

To measure the quality traits of pistachio, a certain number of pistachio clusters were harvested from different parts of the pistachio tree and the average number of nuts in 8 clusters was calculated. Also, the weight of pistachio nuts was measured in eight clusters and the percentage of indehiscent, dehiscent, blank pistachios and ounces of pistachios in the harvested nuts was calculated. To measure the ounces of dehiscent pistachios that are commonly used in the market for sale, the dehiscent pistachios were separated from other pistachios and then their ounces were measured.

Part III. Summary of Research Findings

The effect of KTS, CaTs and KTS+CaTs on soil characteristics

Application of amendments individually or in combination had different effects on soil salinity (EC). Addition of CaTs alone and in combination with KTS decreased electrical conductivity (EC), but KTS applied alone increased soil EC for both depths (Table 2).

Soil pH was moderately alkaline (pH 7.6). The application of both amendments (individually or in combination) did not significantly affect pH compared to the control. This may be due to high buffering capacity of calcareous soils.

Applying CaTs alone significantly decreased soil SAR, but the addition of KTS (individually) increased this parameter. The CaTs applied alone resulted in 22% decrease of soil SAR compared to the control (Table 2). The decline in SAR with application of CaTs indicates Na displacement from the soil exchangeable sites by Ca from CaTs. In general, Ca-containing amendments such as gypsum and CaTs can have an ameliorative effect in saline and sodic soils.

Table 2- Effect of KTS, CaTs and KTS+CaTs on some chemical properties of soil (two depths).

Treatments	Soil Depth	EC (dsm^{-1})	pH	SAR	Ca (meq/L)	Mg (meq/L)	Na (meq/L)
Control	0-40	18.7	7.6	11.7	51	52	83.8
Control	40-80	15.3	7.5	11	50	35	71.5
KTS	0-40	25.3	7.7	15.1	68	64	122.6
KTS	40-80	18.6	7.6	13	50	46	89.9
CaTs	0-40	14.9	7.7	9.1	48.5	41.5	61.3
CaTs	40-80	13.4	7.6	8.7	41	39	55.2
KTS+CaTs	0-40	17.4	7.6	11.4	52	46	79.7
KTS+CaTs	40-80	12.8	7.6	9.1	39.5	33.5	55.2

The effect of KTS, CaTs and KTS+CaTs on leaf characteristics

CaTs and KTs (individually or in combination) had no significant effect on the concentration of macro-elements (N, P, K, Ca, Mg, and Na) in pistachio leaves as compared to the control (Table 3).

The concentration of Fe, Zn, Mn, and Cu in pistachio leaves significantly increased by the addition of CaTs in irrigation water compared to un-treated soil, but applying KTS (individually or in combination) did not significantly affect the concentration of the studied micro-elements compared to the control (Table 3). In the CaTs treatment, 13, 12, 15, 14% increase in the leaf concentration of Fe, Zn, Mn, and Cu were observed respectively compared to control. This may be due to: (i) Thiosulfate is a reducing agent. Fe and Mn are normally found in well aerated soils in the oxidized (Fe^{3+}, Mn^{4+}) forms. Before Fe and Mn can be taken up by plants, however, it must be reduced to Fe^{2+} and Mn^{2+} at the root surface. Thus, thiosulfate possesses the power to increase Mn and Fe availability in calcareous soils, (ii) acidifying power of CaTs. When CaTs applied to the soil, some part of the $S_20_3^{2-}$ converts to elemental S. The elemental S further converts to sulfuric acid, which gives the thiosulfate its acidifying power and (or) (iii) CaTs may decrease soil pH and increase availability of micro-elements by decreasing lime solubility as:

$$CaS_2O_3 + 2O_2 + CaCO_3 + 4NaX \leftrightarrow 2CaX + 2Na_2SO_4 + CO_2$$

Table 3- Effect of KTS, CaTs and KTS+CaTs on concentrations of some macro- and micro elements of pistachio leaf.

Treatments	N	P	K	Ca	Mg	Na	Fe	Zn	Mn	Cu
Control	2.03a	0.08a	1.46a	1.52ab	0.43b	0.23a	67.33a	5.43a	23.00b	15.30a
KTS	2.03a	0.07a	1.42a	1.69a	0.45b	0.23a	73.00a	5.13a	27.67a	14.60a
CaTs	2.10a	0.06a	1.25b	1.34bc	0.76a	0.24a	76.00a	6.03a	26.33a	17.40a
KTS+CaTs	2.00a	0.07a	1.28b	1.28c	0.64a	0.24a	68.33a	5.80a	26.33a	14.27a

*: on the basis of %

**: on the basis of mg kg^{-1} mass dry weigh

The effect of KTS, CaTs and KTS+CaTs on pistachio yield and characteristics

Table 4 shows the average of measured pistachio nut characteristics cv. Ahmadaghaei at harvest for KTS, CaTs and KTS+CaTs treatments. The average number and weight of pistachios (8 clusters), the number and percentage of indehiscent pistachios, the number and percentage of blank pistachios were shown in Table 4. Pistachio weight increased in KTS, CaTs and KTS+CaTs treatments compared to control. This increase was more in CaTs treatment followed by KTS+CaTs and KTS treatments, respectively. Although there was slight changes in the number of pistachio nut, number and percentage of indehiscent and blank pistachios in different treatments, but these differences were not statistically significant.

Table 4- Effect of KTS, CaTs and KTS+CaTs on pistachio nut characteristics cv. Ahmadaghaei at harvest.

Treatments	Nut (n.)	Nut dry weight (gr.)	Indehiscent Nut (n.)	Indehiscent Nut (%)	Blank Nut (n.)	Blank Nut (%)
Control	97.19 a	109.03 b	14.16 a	14.67 a	13.09 a	13.54 a
KTS	101.06 a	114.38 ab	13.91 a	14.15 a	13.22 a	13.07 a
CaTs	103.78 a	117.56 a	19.00 a	18.02 a	14.53 a	14.29 a
KTS + CaTs	99.97 a	115.75 ab	16.00 a	15.79 a	14.13 a	14.41 a

Control: Grower practices.

In addition, the number, percentage and weight of dehiscent pistachios were not significantly affected by KTS, CaTs and KTS+CaTs treatments, meanwhile slight differences were observed in these treatments. Pistachio ounces are shown (Table 5) in two forms; a. harvested pistachios containing the blank, indehiscent and dehiscent nuts and in b. dehiscent nut. Although there were no significant changes in ounces of harvested nuts in different applied fertilizer, but the ounces of dehiscent nut was decreased in CaTs treatment compared to control and other treatments, which indicates the larger size of nuts in CaTs treatment.

Table 5- Effect of KTS, CaTs and KTS+CaTs on pistachio nut characteristics cv. Ahmadaghaei at harvest.

Treatments	Dehiscent Nut (n.)	Dehiscent Nut (%)	Dehiscent Nut (gr.)	Ounce of Dehiscent Nut	Ounce of Harvested Nut
Control	69.94 a	71.79 a	82.78 a	23.98 a	25.29 a
KTS	73.81 a	72.62 a	88.78 a	23.58 ab	25.14 a
CaTs	69.94 a	67.30 a	85.00 a	23.37 ab	25.04 a
KTS + CaTs	69.84 a	69.80 a	86.03 a	22.98 b	24.57 a

Control: Grower practices.

The yield of dried pistachios at harvest time was affected by the fertilizer treatments used. The application of KTS, CaTs and KTS+CaTs during the growing season were increased the yield of dried pistachio significantly. The highest yield (dry nuts) was observed in the tress which received CaTs treatment (1750 kg/ha) compared to the control and other treatments followed by, KTS+ CaTs (1723 kg/ha) and KTS (1703 kg/ha) respectively (Fig. 12). The average of yield for control was 1623 kg/ha. Therefore, the average yield of pistachio tree was increased about 7.8 % in CaTs treatment and 6.16 % and 4.93 % in KTS+ CaTs and KTS respectively.

The number of cluster, nuts in the cluster, and other characteristics of nuts were determined by the reproductive development of flowers in previous year. The results of measuring different parameters in pistachio nuts in table 4 and 5 show that there is some slight differences between the nuts in treated tree and control, but there are significant differences between nut dry weight and the ounces of dehiscent pistachio nuts. The effect of K fertilization on the nut quality and yield in pistachio was studied from 1996 to 1998. The results showed that potassium fertilization at the rate of 110 to 220 kg/ha significantly increased nut yield and quality, but nut yield tended to decrease when the annual rate exceeded 220 kg/ha K (Holtz, 2001). The role of K is more important during the growth of nuts in July and August. In the previous report, there was a significant, positive correlation between nut yield and leaf K concentration during nut fill (Holtz, 2001).

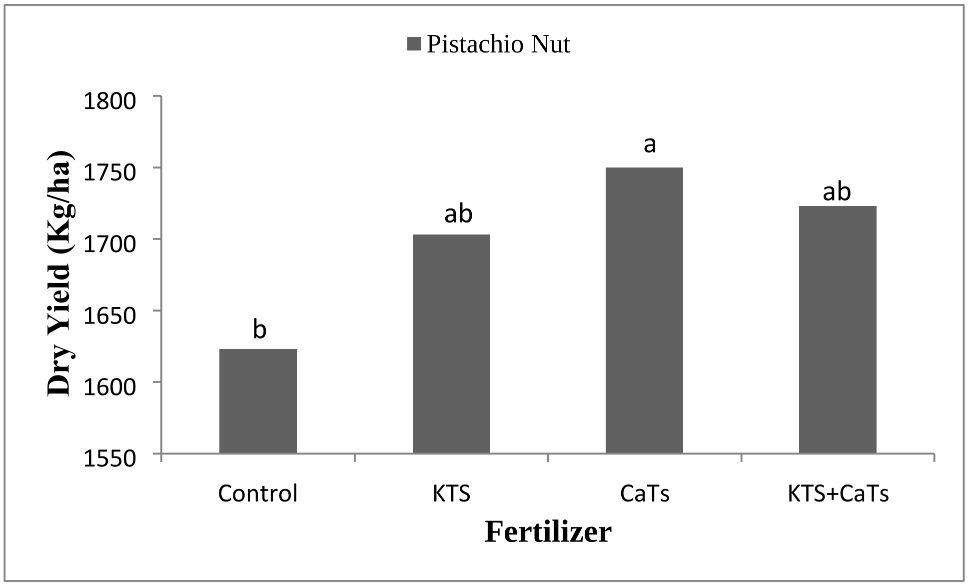

Figure 12- Effect of KTS, CaTs and KTS+CaTs on pistachio dry yield.

The review of fresh pistachio yield in the experiment showed that the application of KTS, CaTs and KTS+CaTs has increased the yield of fresh pistachios (Fig. 13). The application of CaTs alone showed the highest amount of pistachio yield, which is equivalent to 3991 kg/ha, while it was 3929 kg/ha and 3882 kg/ha in KTS+CaTs and KTS respectively. It should be noted that the yield of fresh pistachios in control was 3701 kg/ha.

Increased concentrations of Ca and K under saline conditions would improve root expansion and elongation, which would increase the surface area contact between tree roots and soil nutrients. It is necessary to have a complete nutrition management in combination with soil reclamation for obtaining the higher yield.

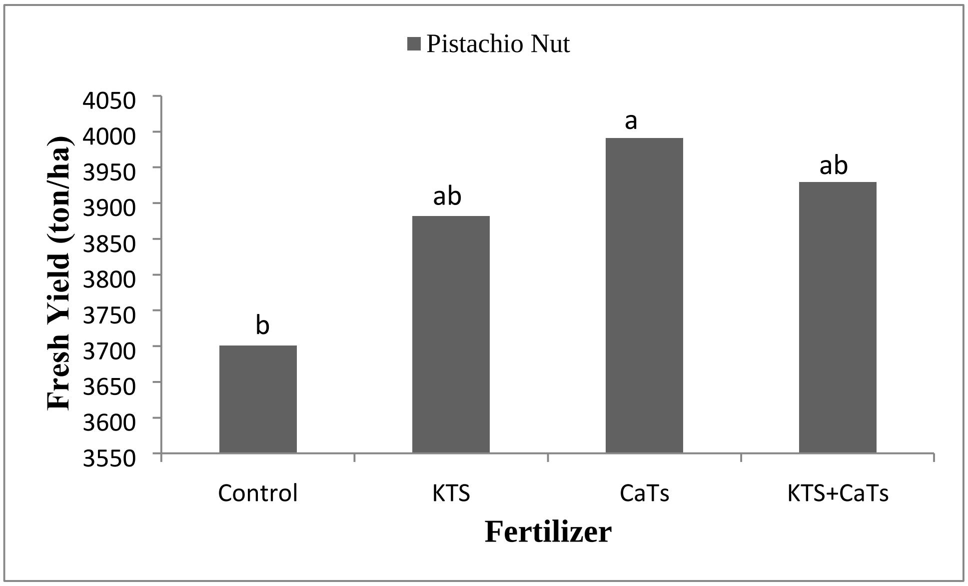

Figure 13- Effect of KTS, CaTs and KTS+CaTs on pistachio fresh yield.

It has been shown that the average yields of pistachio can be more than doubled by optimizing soil management practices (Malakouti, 2006). The problems of pistachio tree nutrition aggravate every year mainly due to high soil pH, high concentrations of bicarbonate in irrigation water as well as high salinity conditions in the orchards. It would be necessary to remove toxic ions at least in the pistachio rhizosphere. Pistachio trees respond favorably to CaTs and KTS fertilizers and the trees tolerance to salinity hazards improves by increasing the K+Ca/Na ratio in soil solution and tree, because a part of absorbed potassium stays within the vacuoles as a counter ion for Cl^- without taking part in the vital catabolic reactions. Therefore, under such conditions, in addition to meeting the nutritional requirements of the trees, salinity hazards can be reduced and yields improved with the application of CaTs and KTS.

Overall Research Findings

In this study we investigated, whether combined application of CaTs and KTs is more effective than single application of them on pistachio yield and improvement of nutrients status of the plants under salinity stress. From the findings, it is clear that:

1. Applying CaTs alone significantly decreased soil SAR. The results obtained suggest that application of CaTs could be an option for reclamation of saline-sodic soils.
2. The concentration of Fe, Zn, Mn, and Cu in pistachio leaves significantly increased by the addition of CaTs but none of the amendments (individually or in combination) had significant effect on the concentration of macro-elements (N, P, K, Ca, Mg, and Na) in pistachio leaves as compared to the control.
3. The application of CaTs, KTS and CaTs+KTS could increase the yield and dehiscent nut ounce but has slight and non-significant effect on the number and percentage of pistachio nut characteristics.

References:

Darijani, F., Veisi, H., Liaghati, H., Nazari, M.R., Khoshbakht, K. 2019. Assessment of resilience of pistachio agroecosystems in Rafsanjan plain in Iran. Sustainability, 11, 1656; doi:10.3390/su11061656.

Holtz. B.A. 2001. Soil K, leaf K concentration, and nut yield and quality of mature pistachio trees. HortScience 36(1):85–89.

Horneck, D.A., Ellsworth, J.W., Hopkins, B.G., Sullivan, D.M. and Stevens. R.G. 2007. Managing Salt-affected Soils for Crop Production. Oregon State University.

Iran Pistachio Association (IPA). http://iranpistachio.org/fa/articles.

Javanshah, A., Aminian Nasab, S. 2016. The effects of humic acid and calcium on morphophysiological traits and mineral nutrient uptake of pistachio seedling under salinity stress. Journal of Nuts 7(2):125-135.

Malakouti, M.J. 2006. Increasing the yield and quality of pistachio nuts by applying balanced amounts of fertilizers. Acta Horticulture. 726, 293-300. DOI: 10.17660/ActaHortic.2006.726.47.

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