# Improving agricultural production under water scarcity in Fars province, Iran

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## ABSTRACT

Water scarcity is one of the major limiting factor for improving agricultural production in the world, which significantly affects agricultural production and livelihood of millions of people who live in arid and semi-arid regions. This case study presents the analysis of the effectiveness of Silica Moisture Absorbent Medium (SMAM, commercially available under the name Sanoplant), with regard to water saving and shortening the crop growth period. A cost-benefit analysis was carried out to assess the long term economic viability of SMAM.

This case study integrates field measurements and observations on plant development, as well as the nitrogen content of the leafs and nitrogen availability in the soil. To assess the effectiveness of SMAM in saving water, enhancing plant growth and reducing mortality rate of crops, 15 scenarios (combinations of water amount and SMAM) were set for each of the three most widely cultivated crops in Iran: orange (*Citrus sinensis*), olive (*Olea europea*) and date (*Phoenix dactylifera*). The scenarios differed in the dosage of SMAM and different irrigation regimes, to find the optimal usage to increase water productivity in Fars agricultural regions, while maintaining a positive cost-benefit ratio. The results show that by using SMAM, the best results can be obtained by using 7 grams of SMAM per kilogram of soil and even decreasing irrigation by 50%.

## INTRODUCTION

Iran is a country with vast potential agricultural lands estimated to be 51 million ha. Fars is one of the 31 provinces and it’s capital Shiraz is known as the cultural capital of the country, this province is located in the southern part of the country, but is not bordering to the Persian Gulf. A large part of the agricultural land in Iran is situated in this province. However, approximately half of this arable land is located in regions that receive average annual rainfall in a range from 50 mm to 400 mm (Ghahraman 2006, FPRWD 2004). Water scarcity is the major limiting factor for improving agricultural production (Sadeghi et al. 2002) and improving livelihood of the rural population (Keshavarzi et al. 2006, FPRWD 2004, Azizi et al. 2009, Chalbiyan 2007). Additional factors that contribute to water scarcity, lower agricultural production, and the imbalance between food demand and supply in Iran include: deforestation, land degradation, population pressure which is increasing at an annual rate of 1.1%, (Alizadeh 2008) plus lack of appropriate and adaptive water management (Hassanli et al. 2009).

The simplest definition of water scarcity is “imbalance between the availability of water and the demands for it” (Keshavarzi et al. 2006, Hassanli et al. 2009). Therefore, decreasing water feeding in agricultural sectors especially during drought is important to save water, which can then be used for different purposes.

It is important to reduce water losses by using modern irrigation systems (Alizadeh 2008). In Fars province, the present water productivity (the amount of water required per unit of yield) is about 25% to 30% of normal value in Iran (FPRWD 2004, Mohsenzadeh and Hortamani 2006). Agriculture is the activity that has the highest water consumption but in times of water scarcity it also reduces water use as well (Kramer and Boyer 1995, Azizi et al. 2009, Sadeghi et al. 2002). The overall objective of this research was to analysis to what extent can the use of Silica Moisture Absorbent Medium (SMAM), enhance agricultural production per unit quantity of water and per unit cost.

It has been recognized that rainfall is very erratic in nature (Keshavarzi et al. 2006, FPRWD 2004) therefore, the government has made an effort to minimize the degree of uncertainty of water supply by constructing dams and reservoirs, and using modern water saving technologies such as drip and sprinkler irrigation systems that are gradually replacing the more traditional systems (Moosavinia 2002, Nejahi 1992, Van der Perk 2006).

SMAM is a water protection material mainly made of natural silicates. This material can be used for soil improvement in sandy soils or aerated substrates, SMAM can hold a large amount of water and nutrients, especially in the water tension range that plants can access. The water holding capacity of SMAM is higher than normal sand, SMAM is granulated through a special method using special silica that has been enriched with carbon and cellulose, in order to increase the size of the material and thereby make it easier to spread on (Nabeel Badawy and Zaid 2005).

## MATERIALS AND METHODS

In order to assess the usefulness of SMAM in reducing irrigation demands of crops and maintaining satisfactory yields, a pot experiment was carried out.

The experimental design consisted of a full factorial set-up with three levels of SMAM (0, 50 or 100 grams per pot); five irrigation regimes (0, 12.5, 25, 50 or 100% of the common irrigation regime in this region) and three crops (date, olive and orange, Fig 1). Each combination was replicated three times in a representative greenhouse for this region. Each pot contained 7 kilograms of a native sandy soil. One-year old seedlings that were grown in the same greenhouse were transplanted to single plastic pots which were free draining. These seedlings had been cultivated under a normal irrigation regime.

The SMAM used in this experiment was obtained from Sanoway company under the brand name Sanoplant (chemical characteristics of SMAM provided in Table 1). SMAM application was done during transplantation of the seedlings at the start of the experiment.

The greenhouse was a glasshouse, all pots were located in the same compartment, temperature was set to 20° C and humidity was set to 45%. Irrigation was done manually by pouring fixed amount of water onto the top of the pots. This was done twice per week for olive and orange and once per week for date.

Three months after the start of the experiment, plants were destructively analysed. The number of leaves per plant was counted manually, and the total height of the shoot was measured. Subsamples from the soil were taken to determine pH and EC. Subsequently, the roots were cleaned by soaking them in water, after which fresh weight and dry weight of the root system were determined (Fig 2,3). A subsample of the leaves was taken to determine the nitrogen concentration through the Kjeldahl method (International Dairy 2009, Persson, Wennerholm and Tecator 1995).

**Table 1.**
**Chemical characteristics of SMAM**

| Characteristic | Value |
|---|---|
| N | 0.61% |
| $P_2O_5$ | 0.03% |
| $K_2O$ | 0.06% |
| CaO | 0.06% |
| $CO_2$ | 0.00% |
| MgO | 0.96% |
| $H_2O$ | 9.06% |
| ash | 85.6% |
| sand, clay | 0.72% |
| $SiO_2$ | 56.60% |
| pH * | 7.2 |
| Cu | 34.0 mg/kg |
| Zn | 80.0 mg/kg |
| Pb | 13.0 mg/kg |
| Cd | <0.5 mg/kg |
| Cr | 60.0 mg/kg |
| Ni | 1.0 mg/kg |

***** pH (10% water leachate)
(Nabeel Badawy and Zaid 2005)

At the end of the research, leafs were counted one by one manually, for measuring the tallness of samples, normal measure tape used (Moosavinia 2002). Stem tallness measured from the shoot that comes out of the soil, up to the terminal bud which located at the end of shoot (Mohsenzadeh and Hortamani 2006). Roots were cut from the shoot and weights of them were measured while they were wet by digital balance. Again, they have been put in to the oven to become completely dry through 60ºc, it took one and half days to make roots fully dry and be ready for root mass measurement (Mohammadi 2008). Furthermore, in this research MSTAT-C (Dr.O.Nelsson 1983, Mirzaee; 1996) had used for scientific evaluation and to compare the mean value of research result through Duncan statistical test method.

**Fig 1. Research samples (from left: date, olive and orange)**

**Fig 2,3 Olive root structure due to treatments**

## RESULTS

**Plant measurements**

The results in this section are for olive, since the results for the other crops show similar trends. Fig. 3 to 6 shows the percentage of nitrogen in olive, number of leafs, height of steam and root biomass respectively. All figures shows the trend at 50 grams of SMAM per pot, irrigation can be decreased or even cancelled without effect on result, but does highest result provide the best?, is the question which needs more research on. Fig 3. shows the result on nitrogen concentration which is steady for 50 gr of SMAM, in different irrigation regime while the treatments without SMAM suffered a strong reduction when irrigation was decreased. Nitrogen concentration seemed to increase with decreasing irrigation levels at 100 gr SMAM per pot, this trend was found in the other crops too, and requires more research to explain mechanistically. Other figures clearly shows that in category of 50 gr of SMAM and 500 ml of irrigation the best result was achieved.

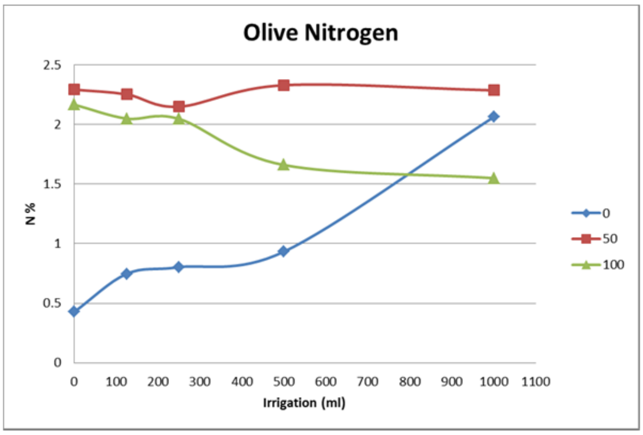


**Fig 3. Olive leaf nitrogen concentration (%)**

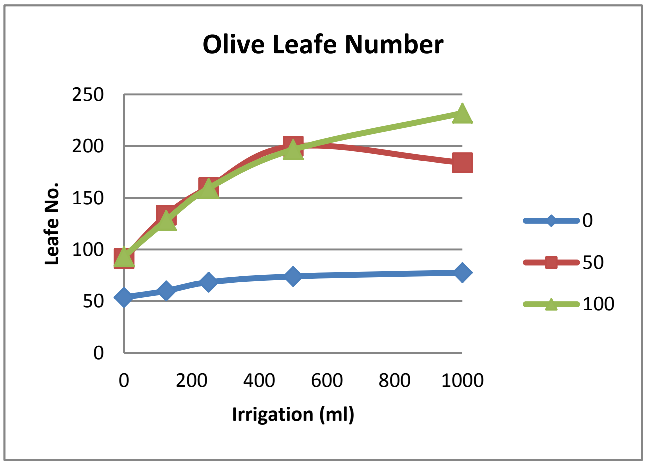


**Fig 4. Number of leaves per plant**

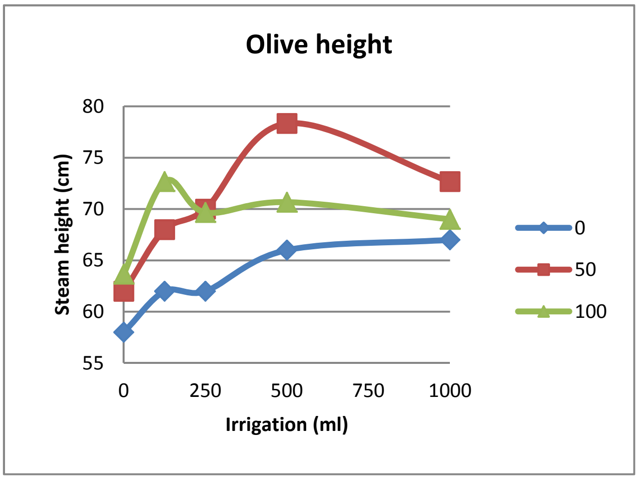


**Fig 5. Plant height**

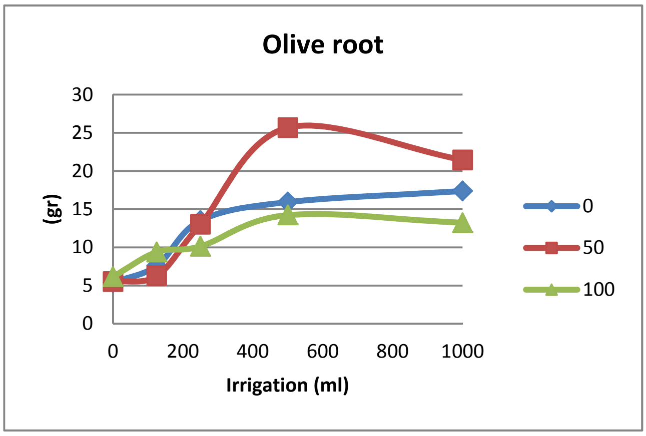


**Fig 6: Root biomass (dry weight, gr per plant)**

**Cost-Benefit analyses**

Considering to the agricultural areas and normal amount of crops per area in Fars Province, detail calculation of Cost Benefit analysis of all three samples are providing via Table 2.

**Table 2. Cost-benefit ratio on a per-hectare basis.**

| | | Orange | Olive | Date |
|---|---|---|---|---|
| Savings by reducing irrigation with 50%, summed over 10 years | €/ha | 14,000 | 7,000 | 12,000 |
| SMAM cost, use for 10 years | €/ha | 12,000 | 10,000 | 4,000 |
| Cost-benefit ratio | - | 1.2 | 0.7 | 3 |

A cost-benefit ratio higher than 1 is regarded positive, which means that it is profitable to use SMAM in the case of orange and date, but not for olive.

## DISCUSSION

This study was the first practical research with SMAM in Iran and made an effort to provide advice on how to improve agricultural productivity. As previous figures shows, by 50gr of SMAM we have increasing in all result up to 50% of irrigation but to reach appropriate answer to the question of “Is the highest value is the best?” more research requires in detail. Regarding the cost-benefit analysis, it seems that the use of SMAM can be profitable in certain crops and is able to reduce the irrigation demand by 50%. Therefore, water can be saved via SMAM, which is important given to the intensification of water scarcity which negatively affects the agricultural regions (Keshavarzi et al. 2006).

## CONCLUSION

In the soil, SMAM acts as a buffer, so it allows longer intervals between irrigation events with higher amounts of water per irrigation event. Without SMAM, access water quickly drains to below the root zone and is lost to the crop. Therefore, until providing better irrigation systems and also, farmers receive better instructions on water management, SMAM can help in improving water productivity. By reducing percolation to the groundwater, also nutrient losses can be decreased, which is beneficial to agricultural productivity (Postlethwait et al. 1996, Sadeghi et al. 2002). In addition, water cost for irrigation is another important factor, which should be taken into account (Mohsenzadeh and Hortamani 2006).

In conclusion: when better irrigation systems and improved education to the farmers are not feasible, the use of SMAM to improve water productivity is a good alternative.

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