



## Effect of solarization on nutrient availability, enzyme activity and growth of pomegranate (*Punica granatum*) air-layered on various potting mixtures

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### ABSTRACT

Pomegranate air layers are generally raised on potting mixture consisting of soil, sand and FYM/vermicompost in the nursery. Increasing concern over the impact of chemical fertilizers and pesticides on the environment for raising disease-free vigorous planting materials necessitate the exploitation of renewable solar energy for disinfecting growth medium and at the same time its enrichment with respect to plant nutrients. Solarization of components in the potting mixture (soil: sand: farmyard manure, 1:1:1, soil: sand: vermicompost, 1:1:1 and soil: sand, 1:1) and their use in various combinations [soil (nonsolarized, NS):sand (nonsolarized, NS):FYM (nonsolarized, NS); soil (solarized, S):sand (solarized, S):FYM (solarized, S); soil (S):sand (S):FYM (NS); soil (NS):sand (NS):vermicompost (NS); soil (S):sand (S):vermicompost (S); soil (S):sand (S):vermicompost (NS); soil (NS):sand (NS); soil (S):sand (S)] was evaluated for production of vigorous air-layer planting materials of pomegranate. Mixing of farmyard manure to solarized soil-sand media significantly increased available nutrient status (particularly P and K), alkaline and acid phosphatase activity and plant growth and vigour as indicated by chlorophyll content (SPAD value), photosynthetic and transpiration rate. Weed population also got reduced significantly. On the contrary, mixing of vermicompost to solarized soil-sand media did not result in any positive impact on plant growth over non-solarized and solarized soil-sand-vermicompost mixtures. With only soil-sand as potting media, non-solarized media recorded higher plant growth, nutrient availability (P and K) and enzyme activity (alkaline phosphatase and acid phosphatase) over solarized one but reduction in dehydrogenase activity and weed population were noted upon solarization of the said medium.

**Key words:** Enzyme activity, Plant growth, Pomegranate, Potting media, Soil fertility, Solarization

Pomegranate (*Punica granatum* L) is an economically important commercial fruit crop belonging to family 'Punicaceae'. It is mainly propagated through air-layers for commercial cultivation. Success of commercial cultivation depends largely on the disease free, vigorous planting materials besides other production factors. For this reason, air-layered material needs to be raised on disease free, nutrient enriched media in the nursery after its detachment from mother plants. Various potting mixtures have been evaluated for raising vigorous pomegranate air-layered saplings (Marathe *et al.* 2010). The increasing concern about the economy of sapling production and more particularly the impact of mineral fertilizers, fungicides and herbicides on

the environment and human health has reduced the use of these products. Among the various alternative strategies, solarization seems one of the most promising techniques to control soil-borne plant pathogens and weeds (Stapleton 2000). In addition, solarization often promotes plant growth by disease-independent mechanisms such as release of mineral nutrients (Chen *et al.* 1991, Grunzweig *et al.* 1993) and stimulation of plant growth promoting rhizobacteria (PGPR) (Scopa *et al.* 2008). Solarization mediated favourable effects were observed in watermelon (Ozores-Hampton *et al.* 2005), cauliflower, fennel (Campiglia *et al.* 2000), black pepper (Sainamol *et al.* 2003) and strawberry (Logascio *et al.* 1999). Little efforts have been made to evaluate the effect of solarization on growth performance of pomegranate saplings and soil chemical and microbiological parameters under nursery condition.

The aim of this study was to investigate the impact of solarization on nutrient availability, weed suppression and microbiological parameters of various potting media and growth of pomegranate air-layered saplings raised thereon.

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## MATERIALS AND METHODS

This study was conducted at Research Farm, National Research Centre on Pomegranate, Solapur, located at 17°68' N latitude and 75°91' E longitude during 2008–09. The properties of the soil used for preparing potting mixture were: pH (soil:water, 1:2.5) 7.7; electrical conductivity 0.25 dS/m; organic carbon 0.21%; calcium carbonate 11.61%; cation exchange capacity 46 cmol (p<sup>+</sup>)/kg. The soil was clayey in texture with 30.8% sand, 20.9% silt and 48.3% clay. Taxonomically the soil is categorized as Entisol (*Typic Ustorthents*). The characteristics and nutrient content of farm-yard manure were: pH 7.52; organic carbon 39.4%; total N 1.10%; total K 2.00%; total P 0.42%; C/N ratio 35.82; extractable Fe 5.56 mg/kg; extractable Zn 8.37 mg/kg; extractable Mn 7.68 mg/kg; extractable Cu 0.75 mg/kg, while the same for vermicompost were: pH 7.60; organic carbon 15.4%; total N 1.65%; total K 1.20%; total P 0.92%; C/N ratio 11.24; extractable Fe 8.65 mg/kg; extractable Zn 16.50 mg/kg; extractable Mn 13.55 mg/kg; extractable Cu 0.94 mg/kg. Three types of potting mixture were prepared in duplicate by mixing (i) soil and sand in 1:1 proportion, (ii) soil, sand and FYM in 1:1:1 proportion and (iii) soil, sand and vermicompost in 1:1:1 proportion. For solarization, the mixtures were spread in beds of 3 m width, 15 m length and 30 cm height from February to March. The beds were leveled, sprinkled with water up to field capacity and left as such for 48 hr to facilitate germination of fungal spores and weed seeds. One set of beds were covered with transparent polyethylene film of 100 $\mu$  thickness for six weeks (during April to May). The edges of polyethylene sheet were tucked inside the soil to make it air-tight. The other set of beds were kept un-covered for the same (above mentioned) period. After solarization, the mixture was used for filling pots of size 30 cm  $\times$  30 cm. Similarly, nonsolarized FYM and vermicompost were also mixed with solarized soil and sand in 1:1:1 proportion separately, which were also used as potting mixture in treatments. The trial was laid out in completely randomized design (CRD) consisting of eight treatments with three replications and three plants in each replication. Forty-five days old air-layered stems of pomegranate cv. Bhagawa were planted one in each pot containing various potting mixtures as per treatments. Treatments used in the experiment were identified as follows: T<sub>1</sub>- Non-solarized soil + non-solarized sand + non-solarized FYM (1:1:1); T<sub>2</sub>-solarized soil + solarized sand + solarized FYM (1:1:1); T<sub>3</sub>- solarized soil + solarized sand + non-solarized FYM (1:1:1); T<sub>4</sub>- non-solarized soil + non-solarized sand + non-solarized vermicompost (1:1:1); T<sub>5</sub>- solarized soil + solarized sand + solarized vermicompost (1:1:1); T<sub>6</sub>- solarized soil + solarized sand + non-solarized vermicompost (1:1:1); T<sub>7</sub>- non-solarized soil + non-solarized sand (1:1); T<sub>8</sub>- solarized soil + solarized sand (1:1).

Samples of potting mixture were collected soon after solarization and were assayed for dehydrogenase enzyme

activity, alkaline phosphatase and acid phosphatase enzyme activity (Page *et al.* 1992) after passing through 2 mm sieve. Samples collected just after solarization and six months after planting were air-dried and ground to pass through 2 mm sieve and were analyzed for available N, P, K and DTPA extractable Fe, Mn, Zn and Cu by following standard procedures (Jackson 1978).

Observations on weed population were recorded 45 days after planting. Measurements on leaf area (using portable area meter, LI-COR NI300C), chlorophyll content (using chlorophyll meter, KONICA MINOLTA SPAD-502 as indicated by SPAD value), photosynthetic and transpiration rate (using LI-COR LI-6400 portable photosynthesis system) were recorded 6 months after planting. The dry weight of stem, leaves and roots of plants were recorded separately after drying at 60°C and added together to record total biomass. The oven-dried plant samples were grounded, mixed well and representative samples were wet digested in di-acid mixture (9 HNO<sub>3</sub>: 4 HClO<sub>4</sub>) and analyzed for P following Vanadomolybdo phosphoric acid method (Jackson 1978), potassium by flame photometer, ELICO CL 361 (Jackson 1978) and micronutrients especially, Fe, Zn, Mn and Cu by atomic absorption spectrophotometer 'Perkin A Analyst 400'. For N determination, representative plant samples were digested separately and analyzed using micro-Kjeltech™ 2100 system. Total nutrient uptake in the above ground plant parts was calculated on the basis of nutrient content in above ground plant parts and their respective dry-mass. Data were analyzed statistically using analysis of variance (ANOVA). Significance was evaluated in all cases at  $P < 0.05$  (Panse and Sukhatme 1985).

## RESULTS AND DISCUSSION

### Soil fertility

Soil fertility of potting medium was assessed just after solarization and at 180 days after planting (DAP) of pomegranate. The data (Tables 1, 2) revealed that solarization of two components (i.e. soil and sand) and all the components in soil-sand-FYM potting medium decreased mineralizable nitrogen but increased available phosphorus and potassium content. The increase was the maximum, when non-solarized FYM was mixed with solarized soil-sand. This increasing trends in available phosphorus and potassium content persisted even up to 180 DAP in soil (S)-sand (S)-FYM (NS) medium. DTPA extractable Cu got increased in solarized soil-sand-FYM medium but decreased in soil (S)-sand (S)-FYM (NS) medium in comparison with non-solarized one. Over a period of 180 days of crop grown, there was increase in DTPA extractable Fe, Mn and Cu in solarized soil-sand-FYM medium. In soil-sand-vermicompost medium, solarization of two components (i.e. soil and sand) and all the components decreased mineralizable nitrogen at 0 DAP but at 180 DAP, there was increase in mineralizable nitrogen in solarized soil-sand-vermicompost medium.

Solarization of soil and sand in the said medium increased available phosphorus both at 0 DAP and 180 DAP, whereas solarization of all the components in the said medium decreased available phosphorus content at 0 DAP. Available potassium content got reduced both at 0 DAP and 180 DAP upon solarization of two components (i.e. soil and sand) and all the components of said medium. The data also indicate that DTPA extractable micronutrient (Fe, Mn, Cu and Zn) status got increased in solarized soil-sand-vermicompost medium over non-solarized one. With soil-sand as potting

medium, solarization of both the components decreased available phosphorus and potassium content. Over a period of 180 days of crop growth, there was increase in mineralizable nitrogen and decrease in available phosphate content of solarized soil-sand medium in comparison with non-solarized one. With the passage of time and crop uptake, DTPA extractable Mn, Cu and Zn content got reduced in solarized soil-sand medium (Table 2).

The increased availability of potassium and phosphorus in soil (S)-sand (S)-FYM (NS) and solarized soil-sand-FYM

Table 1 Influence of solarization on available major nutrient content (mg /kg) of various potting mixtures

Treatment	0 DAP			180 DAP		
	Available N	Available P	Available K	Available N	Available P	Available K
Soil (NS) + sand (NS) + FYM (NS), (1:1:1)	96.76	1.46	53.02	72.80	0.78	91.00
Soil (S) + sand (S) + FYM (S), (1:1:1)	81.67	1.60	76.83	74.12	0.77	100.75
Soil (S) + sand (S) + FYM (NS), (1:1:1)	89.13	2.16	101.83	76.69	1.03	105.00
Soil (NS) + sand (NS) + vermicompost (NS), (1:1:1)	152.06	2.59	163.00	118.30	1.03	127.33
Soil (S) + sand (S) + vermicompost (S), (1:1:1)	140.39	1.73	42.17	132.30	1.05	43.25
Soil (S) + sand (S) + vermicompost (NS), (1:1:1)	102.82	6.44	38.00	99.55	1.51	48.84
Soil (NS) + sand (NS), (1:1)	58.95	1.36	82.17	56.46	0.48	71.93
Soil (S) + sand (S), (1:1)	58.49	0.93	61.00	63.13	0.40	70.08
SE(m) ±	1.39	0.03	2.27	2.36	0.02	1.24
CD (P = 0.05)	2.94	0.06	4.80	5.01	0.05	2.63

S, Solarized; NS, non-solarized

Table 2 Effect of solarization on DTPA extractable micronutrients content (mg/kg) of various potting media

Treatment	0 DAP				180 DAP			
	DTPA extractable				DTPA extractable			
	Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn
Soil (NS) + sand (NS) + FYM (NS), (1:1:1)	13.77	25.03	3.17	3.81	15.11	23.46	10.36	4.77
Soil (S) + sand (S) + FYM (S), (1:1:1)	15.01	27.73	3.99	3.15	17.29	31.45	17.24	5.16
Soil (S) + sand (S) + FYM (NS), (1:1:1)	12.53	30.56	2.74	4.23	11.75	26.19	10.77	5.17
Soil (NS) + sand (NS) + vermicompost (NS), (1:1:1)	28.62	28.96	3.34	5.51	28.73	29.57	10.66	7.57
Soil (S) + sand (S) + vermicompost (S), (1:1:1)	62.71	38.18	5.86	7.24	32.89	22.02	12.67	6.38
Soil (S) + sand (S) + vermicompost (NS), (1:1:1)	12.00	44.62	3.11	5.58	7.44	19.00	9.57	5.14
Soil (NS) + sand (NS), (1:1)	8.81	19.11	2.30	1.65	7.05	14.67	11.32	2.10
Soil (S) + sand (S), (1:1)	9.14	23.81	2.54	1.59	6.46	11.94	7.43	1.51
SE(m) ±	1.20	3.56	0.16	0.33	0.49	1.11	0.55	0.23
CD (P = 0.05)	2.55	7.55	0.34	0.69	1.03	2.35	1.17	0.49

S, Solarized; NS, non-solarized

medium resulted from release of nutrients tied up in organic fraction through mineralization of dead microbiota and activity of thermophilic organisms surviving solarization. Vigorous proliferation and activity of FYM inhabitant microorganisms in solarized soil gave rise to maximum increase in available P and K content in soil (S)-sand (S)-FYM (NS) medium. The increase in availability of phosphorus and potassium upon solarization was also reported by Basavaraju and Nanjappa (2000). The increase in DTPA extractable Cu in solarized soil-sand-FYM medium may be attributed to increased solubility of organically bound soil Cu at higher temperature and subsequently release of organically tied micronutrients particularly Fe, Mn and Cu through mineralization of dead microbial biomass resulted increase in DTPA extractable Fe, Mn and Cu at 180 DAP. The reduction in mineralizable N content both in soil (S)-sand (S)-vermicompost (NS) and soil (S)-sand (S)-vermicompost (S) may be due to reduction in microbial population (as indicated by dehydrogenase enzyme activity) caused by solarization. Furthermore, microorganisms surviving solarization rapidly recolonized in solarized soil-sand-vermicompost medium which gave rise to higher mineralizable N in the said medium in comparison with that in soil (S)-sand (S)-vermicompost (NS) medium at 180 DAP. Faster multiplication of microorganisms present in vermicompost within the solarized soil-sand gave rise to higher alkaline phosphatase enzyme activity, thus higher available phosphorus content was recorded in soil (S)-sand (S)-vermicompost (NS) medium. As the soil-sand-vermicompost mixture initially had high available potassium content, the process of solarization (i.e. wetting and drying) might have resulted reduction in available potassium content in the said medium both at 0 DAP and 180 DAP. This observation was in compliance with that reported by Chittamart *et al.* (2010). However, higher DTPA extractable Fe, Mn, Cu and Zn in solarized soil-sand-vermicompost medium may be attributed to the release of organically tied nutrients in the form of dead tissues through mineralization. Similar observations on temperature induced mobilization/immobilization of micronutrients particularly Cu, Mn, and Fe were reported by Stevenson and Fitch (1981). With soil-sand potting medium, an increase in available phosphorus content in solarized soil-sand mixture may be attributed to phosphate solubilizing activity of thermophilic bacteria (*Bacillus* sp.) and fungi (*Aspergillus* sp. and *Penicillium* sp.), which usually survive the solarization process (DeVay and Katan 1991). On the other hand, wetting and drying during solarization might have resulted in fixation of potassium into the interlayer position of expandable minerals in soil. With the passage of time, reduced microbial activity in solarized soil and crop uptake resulted in reduction of DTPA extractable Fe, Mn, Cu and Zn content. Mineralization of dead organisms in solarized soil subsequently gave rise to higher mineralizable N content at 180 DAP.

#### Enzyme activity

**Dehydrogenase activity:** The data in Fig 1 indicate that solarization of two components (i.e. soil and sand) and all the components in soil-sand-FYM medium caused reduction in dehydrogenase activity. The lowest dehydrogenase activity was recorded in solarized soil-sand-FYM medium. On the other hand, dehydrogenase activity increased in solarized soil-sand-vermicompost medium but decreased in soil (S)-sand (S)-vermicompost (NS) medium. In soil-sand potting medium, solarization increased dehydrogenase activity (Fig 1).

The population of mesophilic microorganisms decline at faster rate during solarization. Thermotolerant and thermophilic microorganisms usually survive the solarization process, but become weakened and vulnerable to change in their ecosystem (DeVay and Katan 1991). Thus, solarization decreased active microbial population as indicated by dehydrogenase activity in majority of cases over a period of time. This finding is in agreement with that reported by Ros *et al.* (2008). But higher dehydrogenase activity in solarized soil-sand-vermicompost medium may be attributed to the

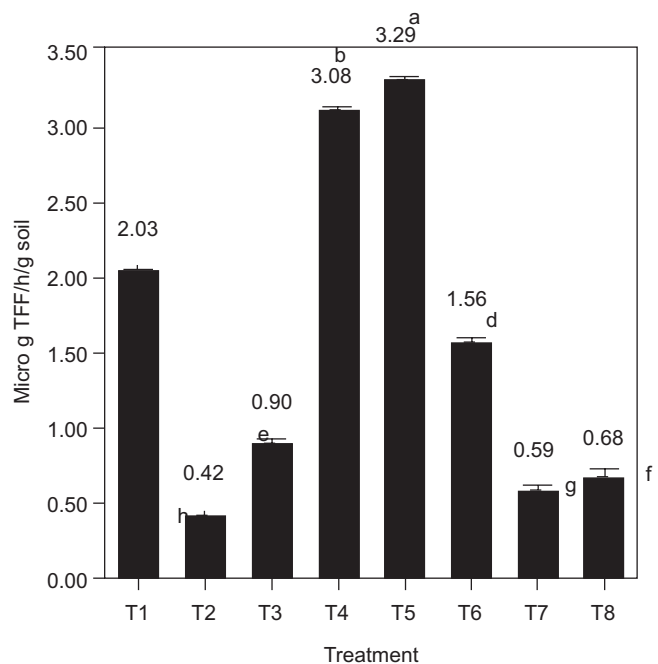


Fig 1 Influence of solarization on dehydrogenase enzyme activity of various potting media (T1- Non-solarized soil + non-solarized sand + non-solarized FYM ; T2-solarized soil + solarized sand + solarized FYM ; T3- solarized soil + solarized sand + non-solarized FYM; T4- non-solarized soil + non-solarized sand + non-solarized vermicompost; T5- solarized soil + solarized sand + solarized vermicompost; T6- solarized soil + solarized sand + non-solarized vermicompost; T7- non-solarized soil + non-solarized sand; T8- solarized soil + solarized sand). Data are averages ( $\pm$  SE) of three replicates. Significant differences ( $P < 0.05$ ) are indicated by different letters

recolonization of highly competitive microorganisms soon after their initial reduction in population owing to solarization (Chen *et al.* 1991).

**Alkaline and acid phosphatase activity:** Mixing of FYM with solarized soil-sand resulted in higher alkaline phosphatase activity at 0 DAP in comparison with that in non-solarized soil-sand-FYM medium. But, solarization of all the components in soil-sand-FYM medium caused reduction in alkaline phosphatase activity while comparing with that in non-solarized soil-sand-FYM medium (Fig 2). With soil-sand-vermicompost medium, solarization of two components (i.e soil and sand) and all the components enhanced alkaline phosphatase activity at 0 DAP over non-solarized one and maximum alkaline phosphatase activity was noted in soil (S)-sand (S)-vermicompost (NS) medium. In soil-sand potting medium, alkaline phosphatase activity got decreased upon solarization.

Solarization of all the components in soil-sand-FYM medium increased acid phosphatase activity over that observed in soil (S)-sand (S)-FYM (NS) and non-solarized soil-sand-FYM media at 0 DAP (Fig 2). With soil-sand-vermicompost medium, solarization of two components and all the components increased acid phosphatase activity over non-solarized one. In soil-sand medium, solarization caused reduction in acid phosphatase activity.

Alkaline and acid phosphatase enzymes mediate the breakdown of organically tied phosphorus. Alkaline phos-

phatase is contributed by microorganisms and acid phosphatase is contributed by both plants and microorganisms. Mixing of FYM to solarized soil (i.e soil and sand) resulted in rapid proliferation of FYM inhabitant microorganisms, thus, higher alkaline phosphatase activity was recorded in soil (S)-sand (S)-FYM (NS) medium. Whereas, recolonization after initial decline of specific thermo-tolerant microorganisms and higher temperature might have contributed towards high acid phosphatase activity in solarized soil-sand-FYM medium (Chen *et al.* 1991). Rapid multiplication of vermicompost inhabitant microorganisms in solarized medium (less competitive environment) might have resulted higher alkaline and acid phosphatase activity in soil (S)-sand (S)-vermicompost (NS) and solarized soil-sand-vermicompost medium. Positive influences of soil solarization on alkaline and acid phosphatase activity have been reported in limited number of studies (Scopa *et al.* 2008). On the contrary, as the soil used in experiment was low in organic C content and solarization caused further reduction in phosphate mobilizing microbial population, which in turn resulted in decreased alkaline and acid phosphatase activity in solarized soil-sand medium.

*Nutrient uptake*

The nutrient uptake data (Table 3) showed that mixing of FYM with solarized soil-sand enhanced N, P and K uptake by plant over non-solarized and solarized soil-sand-FYM medium. There was no significant increase in Fe-uptake by plant upon solarization but solarization of two components (i.e soil and sand) and all the components of soil-sand-FYM medium increased Mn, Cu and Zn uptake by plant. With soil-sand-vermicompost medium, solarization of two components (i.e soil and sand) and all the components caused reduction in N, K, Fe, Mn and Zn uptake by plant. In addition, there was reduction in P uptake by plant in solarized soil-sand-vermicompost medium. In soil-sand medium, plant uptake of major nutrients, viz. N, P and K and micronutrients, viz. Fe, Mn, Cu and Zn got reduced upon solarization of the said medium.

Higher uptake of P and K in soil (S)-sand (S)-FYM (NS) and K in solarized soil-sand-FYM medium may be attributed to their increased availability in the respective media resulting from solarization. Furthermore, higher uptake of Mn, Cu and Zn in soil (S)-sand (S)-FYM (NS) and solarized soil-sand-FYM medium might have resulted from the release of organically tied nutrients upon solarization and increased demand by the crop. Although, solarization of soil and sand in soil-sand-vermicompost medium increased available phosphorus content but it was the proportion of nutrients which decided the nutrient uptake by the plant. Accordingly, availability of nutrients in proper balance in non-solarized soil-sand-vermicompost medium contributed higher uptake of nutrients. Reduced microbial activity and soil availability of major (N, P and K) and micronutrient, viz. Fe, Mn, Cu and

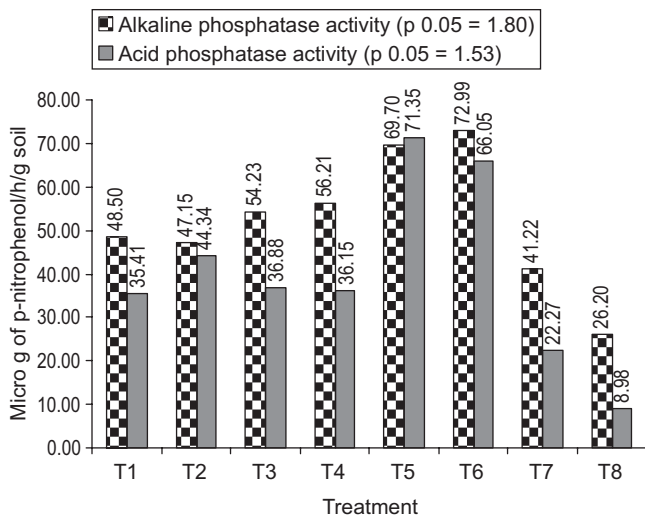


Fig 2 Influence of solarization on alkaline and acid phosphatase enzyme activity of various potting media (T1- non-solarized soil + non-solarized sand + non-solarized FYM ; T2- solarized soil + solarized sand + solarized FYM ; T3- solarized soil + solarized sand + non-solarized FYM; T4- non-solarized soil + non-solarized sand + non-solarized vermicompost; T5- solarized soil + solarized sand + solarized vermicompost; T6- solarized soil + solarized sand + non-solarized vermicompost; T7- non-solarized soil + non-solarized sand; T8- solarized soil + solarized sand)

Table 3 Effect of solarization on nutrient uptake by pomegranate air-layer raised on various potting mixtures

Treatment	N	P (g/ plant)	K	Fe	Mn	Cu (mg/ plant)	Zn
Soil (NS) + sand (NS) + FYM (NS), (1:1:1)	22.80	7.78	3.55	3.70	0.90	1.28	0.53
Soil (S) + sand (S) + FYM (S), (1:1:1)	22.31	7.20	4.07	3.57	1.56	1.95	0.67
Soil (S) + sand (S) + FYM (NS), (1:1:1)	31.05	13.39	5.27	3.89	1.70	1.79	0.82
Soil (NS) + sand (NS) + vermicompost (NS), (1:1:1)	48.20	12.55	7.59	7.28	2.77	3.07	1.37
Soil (S) + sand (S) + vermicompost (S), (1:1:1)	38.74	9.95	5.97	5.30	2.37	3.11	1.08
Soil (S) + sand (S) + vermicompost (NS), (1:1:1)	37.54	13.43	6.53	5.15	2.28	2.18	1.09
Soil (NS) + sand (NS), (1:1)	16.31	6.32	2.81	2.86	1.26	1.53	0.54
Soil (S) + sand (S), (1:1)	11.78	3.02	1.76	2.24	0.78	1.01	0.31
SE(m) ±	0.80	0.45	0.18	0.15	0.06	0.08	0.05
CD (P = 0.05)	1.70	0.96	0.38	0.32	0.12	0.16	0.11

S, Solarized; NS, non-solarized

Zn in solarized soil-sand medium caused reduction in uptake of those nutrients by plants in comparison with non-solarized soil-sand medium.

#### Plant growth

Combining FYM with solarized soil-sand resulted in higher shoot, root and total biomass production as compared to non-solarized and solarized soil-sand-FYM medium (Table 4). Maximum plant biomass was recorded with soil (S)-sand (S)-FYM (NS), followed by solarized and non-solarized

soil-sand-FYM medium. But plant response was quite different with vermicompost in the medium. Higher shoot, root and total biomass were recorded in non-solarized soil-sand-vermicompost medium as compared with that observed in solarized soil-sand-vermicompost and soil (S)-sand (S)-vermicompost (NS) medium. In soil-sand medium solarization decreased shoot and root dry mass production. This in-turn resulted in higher total biomass production in non-solarized soil-sand medium.

The microorganisms surviving solarization of either soil-

Table 4 Effect of solarization on weed population, biomass production and physiological parameters of pomegranate air-layer

Treatment	Weed population (no./pot)	Above ground biomass (g/plant)	Root biomass (g/plant)	Total plant biomass (g/plant)	Leaf area (cm <sup>2</sup> /plant)	Chlorophyll meter reading (SPAD value)	Photo-synthesis rate (µ mol CO <sub>2</sub> m <sup>-2</sup> /sec)	Transpiration rate (m mol H <sub>2</sub> O/m <sub>2</sub> /sec)
Soil (NS) + sand (NS) +FYM (NS), (1:1:1)	9.70 (3.18)	20.49	6.09	26.57	1499.70	29.55	4.86	1.58
Soil (S) + sand (S) + FYM (S), (1:1:1)	0.00 (0.70)	23.49	8.00	31.49	1610.13	36.15	5.06	1.51
Soil (S) + sand (S) + FYM (NS), (1:1:1)	3.70 (1.96)	30.44	10.91	41.34	2029.40	37.49	5.31	1.31
Soil (NS) + sand (NS) + vermicompost (NS), (1:1:1)	11.70 (3.47)	49.53	19.83	69.35	2627.93	39.70	4.93	0.93
Soil (S) + sand (S) + vermicompost (S), (1:1:1)	0.70 (1.05)	39.81	16.83	56.64	1873.72	33.09	4.53	1.04
Soil (S) + sand (S) + vermicompost (NS), (1:1:1)	34.70 (5.92)	37.66	17.38	55.04	2580.81	35.60	4.68	0.97
Soil (NS) + sand (NS), (1:1)	14.00 (3.81)	17.54	8.19	25.73	1002.59	28.68	4.87	1.29
Soil (S) + sand (S), (1:1)	0.00 (0.70)	11.75	5.56	17.31	576.85	26.20	3.10	0.58
SEm ±	0.29	0.33	0.23	0.47	29.51	0.28	0.04	0.04
CD (P = 0.05)	0.61	0.70	0.48	0.99	62.56	0.60	0.09	0.09

S, Solarized; NS, non-solarized; Data in parenthesis are arc sine transformed values

sand or soil-sand-FYM multiplied to a considerable extent in presence of enough of organic matter and played important role in making nutrients available to plant. This may be the reason for getting higher biomass (shoot and root) in soil (S)-sand (S)-FYM (NS) and solarized soil-sand-FYM medium. These reports correspond to a phenomenon known as increased growth response (IGR) that has been attributed to several mechanisms, including increases in nutrient levels in the soil solution, stimulation of beneficial organisms and control of minor pathogens (Gruenzweig *et al.* 1993). On the other hand, balanced nutrients availability in non-solarized soil-sand-vermicompost medium resulted in higher plant biomass production in comparison with solarization treatment of the said medium. In soil-sand medium, death of majority mesophilic microorganisms which also take part in making nutrient available to plant upon solarization resulted reduction in plant growth parameters compared to that in non-solarized soil-sand medium.

#### *Physiological parameters*

Solarization of soil-sand in soil-sand-FYM medium increased total leaf area, chlorophyll content (as indicated by SPAD value) and photosynthetic rate over that observed in solarized and non-solarized soil-sand-FYM medium (Table 4). At the same time, higher transpiration rate was noted in solarized and non-solarized soil-sand-FYM medium. With soil-sand-vermicompost medium, it was the non-solarized one which produced larger leaf area with higher chlorophyll content (as indicated by SPAD value) and in turn had higher photosynthetic rate in comparison with solarization treatment of the said medium. Reduction in total leaf area, chlorophyll content (as indicated by SPAD value) and photosynthetic and transpiration rate were also recorded in solarized soil-sand medium in comparison with non-solarized one.

Higher nutrients availability in soil (S)-sand (S)-FYM (NS) and solarized soil-sand-FYM medium and their uptake caused increase in leaf area, chlorophyll content and photosynthetic rate. Moreover, reduction in transpiration rate on soil (S)-sand (S)-FYM (NS) medium was indicative of higher water use efficiency by the plant. Solarization of two components, (i e soil and sand) and all the components in soil-sand-vermicompost media caused reduction in major and micronutrients uptake by plant. That is why, plant grown on non-solarized soil-sand-vermicompost medium had greater leaf area with higher chlorophyll content and photosynthetic rate. The reduction in leaf area, chlorophyll content and photosynthetic rate upon solarization of soil-sand medium might have resulted from down sizing soil available nutrients content and their uptake by plant.

#### *Weed population*

The data (Table 4) indicated that solarization of two components and all the components of soil-sand-FYM medium significantly reduced weed population. The reduction

in weed population was the maximum with solarized soil-sand-FYM medium, followed by soil (S)-sand (S)-FYM (NS) medium. Solarization of soil-sand-vermicompost medium although caused reduction in weed population but mixing of vermicompost to solarized soil-sand led to increase in weed population in comparison with non-solarized one. In soil-sand medium, there was also reduction of weed population upon solarization.

Higher temperature resulting from solarization might have reduced potential weed pressure by reducing the viability of heat susceptible seeds (Stapleton *et al.* 2002). This observation was supported by the findings of Singh (2006) who achieved better weed control with solarization than with applications of herbicide.

The result of this experimentation indicate that solarization of soil-sand mixture in soil-sand-farm yard manure (1:1:1) potting media enhanced plant growth and vigour through improved nutrition but the same practice in soil-sand-vermicompost (1:1:1) potting media did not yield any extra edge in plant growth over non-solarized one. This shows the potential of using renewable solar energy for raising vigorous pomegranate air-layer on soil-sand mixture amended with farmyard manure in the nursery. Besides cost-effectiveness, solarization can be easily practiced in pomegranate nurseries in tropical countries.

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