Indian Journal of Agricultural Sciences **91** (2): 213–7, February 2021/Article
https://doi.org/ 10.56093/ijas.v91i2.111580

Influence of soil solarization on the multiplication of aeroponic seed potato under net house (Gen-0) and open field conditions (Gen-1) of north central India

MURLIDHAR J SADAWARTI[1], R K SAMADHIYA[1], R K SINGH[2]*, ASHWANI K SHARMA[3], S P SINGH[1], S K SHARMA[1], TANUJA BUCKSETH[2], SUBHASH KATARE[1], Y P SINGH[1], SANJAY RAWAL[4], VINAY SINGH[4], SATYAJIT ROY[4] and S K CHAKRABARTI[2]

ICAR-Central Potato Research Institute, Regional Station, Gwalior, Madhya Pradesh 474 020, India

Received: 04 January 2020; Accepted: 23 November 2020

ABSTRACT

A field experiment was conducted at ICAR- CPRI, Regional Station, Gwalior, Madhya Pradesh to study the effect of soil solarization on weed population and multiplication of seed potatoes under aphid proof net house (Gen-0) and subsequently under field conditions (Gen-1) of 3 potato cultivars, viz. Kufri Mohan, Kufri Chipsona-1 and Kufri Lauvkar during 2017–18 and 2018–19. Treatments were replicated thrice in split plot design. The experimental area was solarized with black polythene and paddy straw mulch, whereas, unsolarized plots served as control. Mean monthly maximum temperature at all the soil depths was higher in polythene solarized plots followed by unsolarized and paddy straw mulch solarized plots under both net house and open field conditions. Soil nutrient properties, viz. *p*H, OC, available N, P and K were influenced by soil solarization both at planting and harvesting. Solarization with polythene and paddy straw mulch resulted in 88.23% and 41.05% reduction in weed population under net house and 74.80 and 37.79% reduction under open field conditions. Under net house conditions, total tuber yield was significantly higher with polythene solarization (29.33 t/ha), whereas, under open field conditions yield was maximum with paddy straw mulch (37.45 t/ha) over other two treatments respectively.

Keywords: Aeroponic minituber, Potato, Solarization, Soil Nutrient, Weed population

Soil solarization refers to covering the soil with transparent sheets/polyethylene, during hot summer for capturing solar energy to heat the soil in the open field or glasshouse which through hydrothermal process brings thermal and other physical, chemical and biological changes in soil (Krueger and Mc Sorley 2009). Soil solarization with plastic mulches has been widely used for food and horticultural crops (Singh and Kamal 2012, Khan *et al.* 2013). Paddy and wheat straw are the commonest mulching materials for fruit and vegetable production (Patil *et al.* 2013). Ramakrishna *et al*. (2006) have reported that polythene mulched soil had significantly higher temperature at 5 and 10 cm soil depths compared to chemical and un-mulched treatments, whereas, paddy straw mulch resulted in lower minimum and maximum soil temperatures. Application of black polyethylene mulch has also been reported to result in lowest species-wise weed count, total weed dry weight (Singh 2012). Horowitz *et al.* (1983) found that weed control was related to the number of days with temperatures above a 45°C threshold. Solarization is affects the nutrient status in the soil. Sofi (2014) reported that the mean *p*H, EC (electrical conductivity), calcium, magnesium, nitrogen, phosphorous, potassium and carbon in solarized soil was significantly higher than non-solarized soil. In potato crop, soil nutrients (N, P and K) were influenced by soil solarization both at the time of planting as well as harvesting (Singh *et al*. 2009).

In India, potato is being grown as a commercial crop in almost all the states under diversified agro-climatic conditions. With continuous increase in the area a proportional increase in seed requirement is envisaged in the future (Singh *et al.* 2012). Aeroponic systems for pre-basic potato seed production was established following increased demand for more efficient, high quality seed production methods (Ritter *et al*. 2001, Nickols 2005) and has a potential of revolutionizing potato seed production industry (Buckseth and Singh 2018) which has been well

Present address: [1]ICAR-Central Potato Research Institute, Regional Station, Gwalior, Madhya Pradesh; [2]ICAR-Central Potato Research Institute, Shimla, Himachal Pradesh; [3]ICAR-Central Potato Research Institute ,Regional Station, Kufri, Shimla, Himachal Pradesh; [4]ICAR-CPRI, Regional Station, Modipuram, Meerut, Uttar Pradesh, [4]ICAR-Directorate of Medicinal & Aromatic Plants Research, Anand, Gujarat. *Corresponding author e-mail: rjan_1971@yahoo.co.in

integrated in India for seed production. Keeping in view the above facts, an experiment was conducted to study the response of soil solarization on weeds, and productivity of aeroponically grown seed potatoes under generation system.

MATERIALS AND METHODS

A field experiment was conducted at ICAR-Central Potato Research Institute, Regional Station, Gwalior, MP during 2017–18 (Gen-0) and 2018–19 (Gen-1) respectively. The experimental was solarized with black polythene and paddy straw mulch while unsolarized plots served as control. Beds for solarization treatment were covered with 50–75 µm thick, low-density polyethylene sheets (SSPM) and 4-5 cm thick paddy straw mulch (PSM) from second week of April to second week November in net house and from second week October in open field. Black polythene sheets and paddy straw was spread on the experimental site and un-solarized beds (US) were left bare during the period. Soil temperatures at 0 cm (surface), 5 cm, 10 cm and 15 cm soil depths in both solarized and unsolarized plots between 13.30 and 14.30 h every day (both years) were recorded and mean monthly temperatures were calculated.

Pre-sprouted aeroponic mini-tubers (4–5g) of three cultivars, viz. Kufri Mohan, Kufri Chipsona-1 and Kufri Lauvkar were planted in 2.0 m × 1.8 m plots at 30 cm × 10 cm spacing in insect-proof net-house (Gen-0) and subsequently (35-40 g tubers) minitubers were planted next year in 3.0 m × 3.0 m plots in open fields at 60 cm × 20 cm spacing (Gen-1), during 3rd week of October. Treatments were replicated thrice in split plot design where solarization treatments as main plot and variety as sub plot. Sprinkler irrigation in net house, whereas and furrow irrigation under field conditions was followed. Seed crop was raised as per seed plot technique. Soil samples taken at planting and at harvest were analyzed for different nutrients, viz. *p*H, EC, organic carbon, available nitrogen, phosphorous and potassium following standard procedures. Data were recorded on various parameters and analyzed statistically.

RESULTS AND DISCUSSION

Soil Temperature: The mean monthly maximum temperatures at all the soil depths was higher in polythene solarized plots followed by un-solarized plots and minimum with paddy straw mulch both under net-house and open field conditions. Under net house, mean maximum soil temperature recorded under the polythene mulch were 39.7°C at the surface, 37.4°C at 5 cm, 35.7°C at 10 cm and 33.8°C at 15 cm soil depth, which were higher by 1.3°C and 3.1°C, 0.6°C and 2.9°C than unsolarized plots and 0.4°C, 2.5°C, 0.4°C and 2.0°C with paddy straw mulch at respective depths (Fig 1). Similarly, under open field conditions, maximum mean soil temperature recorded under the polythene mulch were 45.5°C at the surface, 42.1°C

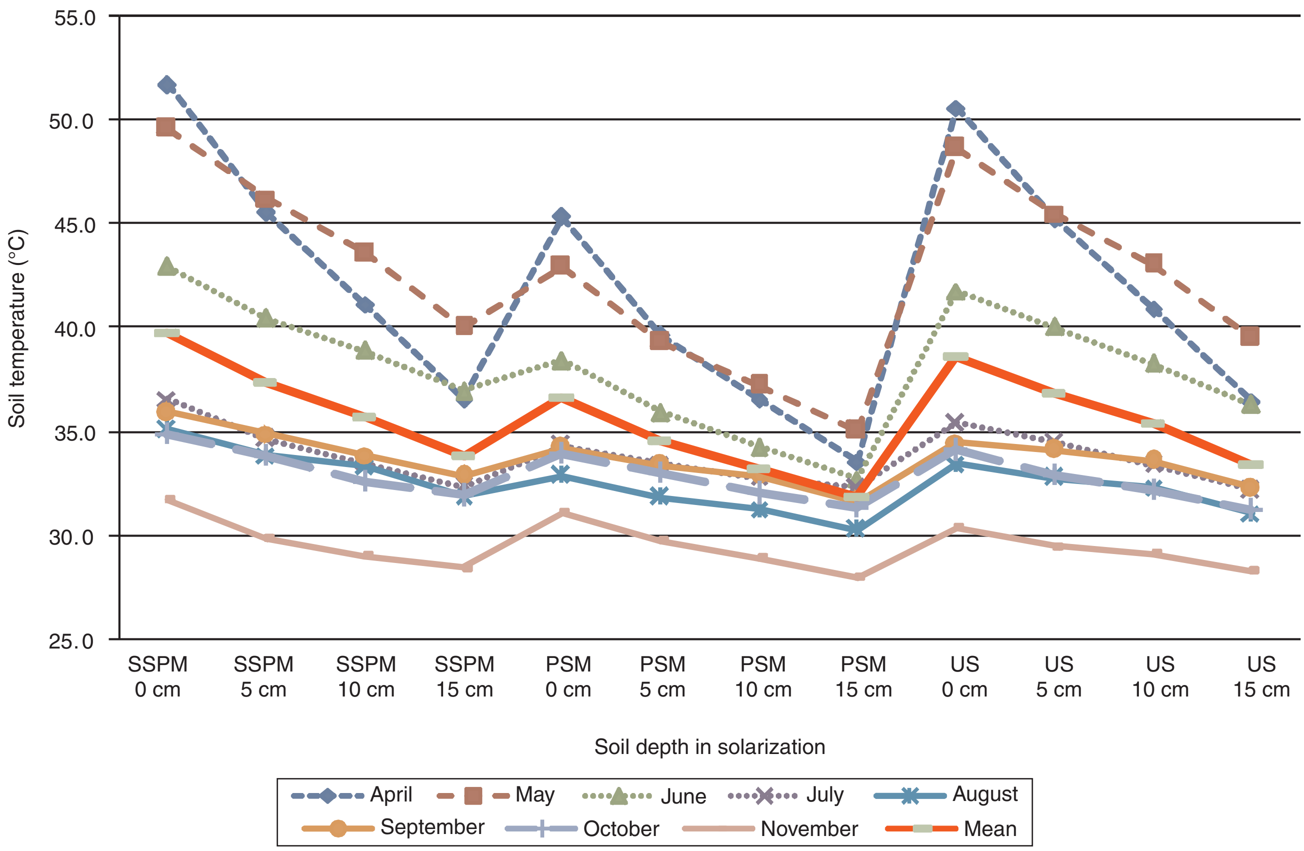

Fig 1 Monthly mean maximum soil temperature (°C) in solarized and un-solarized soil at different soil depths under net house condition (Gen-0).

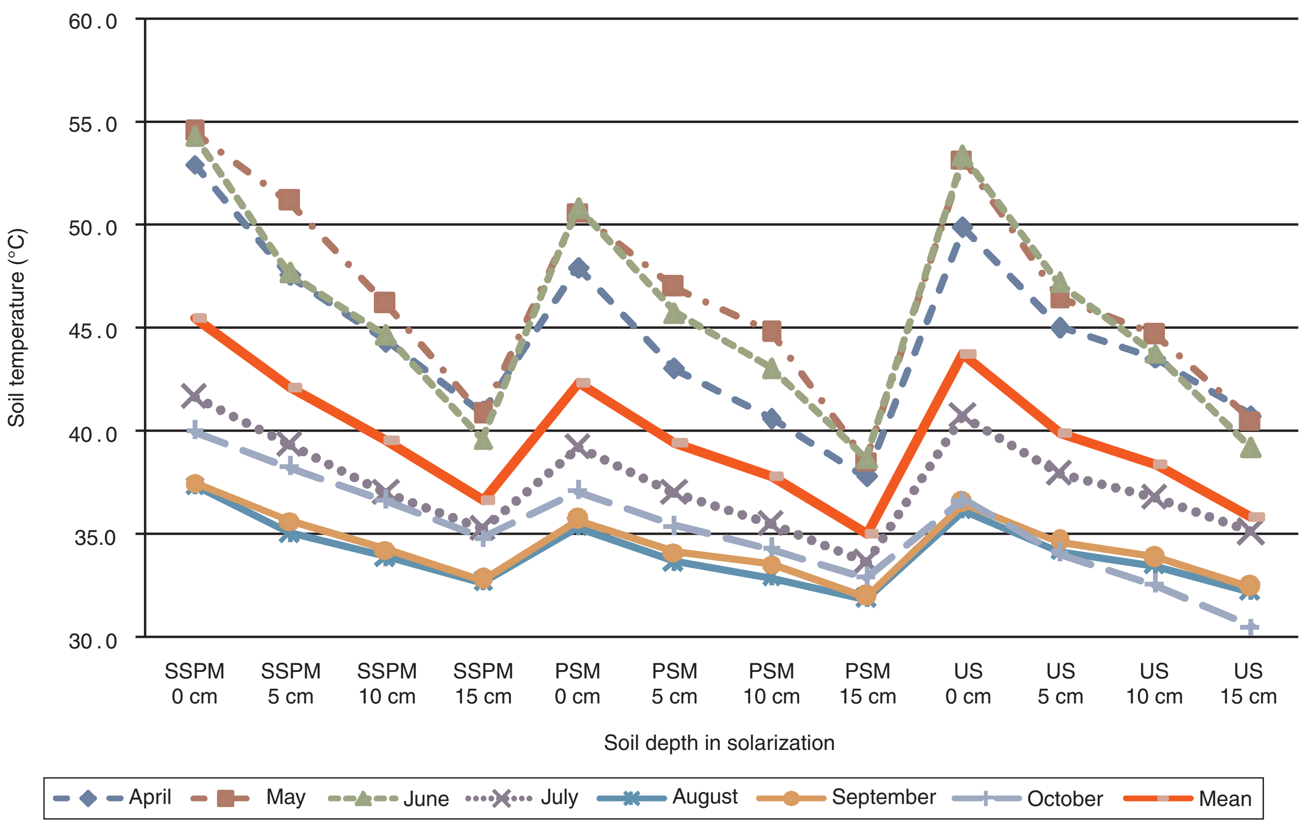

Fig 2 Monthly mean maximum soil temperature (°C) in solarized and unsolarized soil at different soil depths under open field condition (Gen-1).

at 5 cm, 39.5°C at 10 cm and 36.7°C at 15 cm soil depth, which were higher by 1.7°C and 3.1°C, 2.2°C and 2.7°C than unsolarized plots and 1.1°C and 1.7°C and 0.9°C and 1.6°C higher than paddy straw mulch at respective depths (Fig 2). Lower minimum and maximum soil temperatures with paddy straw mulch as compared to polyethylene mulch as recoded in the present study are probably due to the fact that the black polyethylene absorbed more solar radiation

Table 1 Effect of soil solarization and varieties on growth attributes and weed population in Gen-0 and Gen-1

	Generation-0 (Net house)				Generation-1 (Open field)				Weed population (no./M^2)	
Solarization/ varieties	Emergence %	No. of stems/plant	No. of leaves/plant	Plant height (cm)	Emergence %	No. of stems/plant	No. of leaves/plant	Plant height (cm)	Gen-0	Gen-1
Solarization (A)										
SSPM	99.26	1.2	20.9	68.6	91.85	2.8	45.0	55.6	52	127
PSM	97.78	1.4	20.6	64.9	92.15	3.6	46.1	49.2	72	175
US	99.63	1.4	21.3	66.2	91.55	2.8	48.7	48.0	96	242
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	7.5	14.3
Varieties (B)										
K. Mohan	98.52	1.2	21.8	65.8	93.92	2.9	43.9	53	72	184
K. Chipsona 1	98.7	1.3	23.4	77.5	93.19	3.0	56.6	53.6	69	181
K. Lauvkar	99.44	1.6	17.6	56.3	88.44	3.2	39.3	46.2	78	180
CD (P=0.05)	NS	NS	1.55	4.46	NS	NS	3.90	5.42	5.0	NS
Factor (B) at same level of A	NS	NS	2.86	8.71	NS	NS	7.78	NS	9.6	NS
Factor (A) at same level of B	NS	NS	2.63	9.44	NS	NS	9.15	NS	10.2	NS

SSPM, Soil solarization with polythene mulch; PSM, Paddy straw mulch and US, Unsolarized soil.

compared to paddy straw mulch, as already reported by Sarkar and Singh (2007).

Soil nutrients: Soil nutrients properties were influenced by soil solarization both at planting and harvesting. All the solarization treatments resulted in slight increase in *p*H of soil both under net house and open field at harvest, whereas, no change was recorded in EC. With paddy straw mulch, slight decrease in organic matter (%) was recorded at harvest both under net house and open field. Reduction in N and P and improvement in K was reported in all the treatment at harvest in both net house and open field conditions. Singh *et al.* (2009, 2012) have also reported that solarization influences soil nutrients (N, P and K) in potato both at the time of planting and harvesting.

Growth parameters: Emergence of tubers under Gen-0 and Gen-1 was not significantly affected by solarization (Table 1). Similar results were reported by Singh *et al.* (2009 and 2012). Plant emergence among different varieties was also statistically similar in both, Gen-0 and Gen-1 crops which ranged from 98.70–99.44% in Gen-0 and 88.44–93.92% in Gen-1 (Table 1). Non-significant differences were recorded in number of stems per plant, compound leaves and plant height among solarization treatments and control both in Gen-0 and Gen-1 stages of seed multiplication. Kufri Mohan and Kufri Chipsona-1 recorded significantly higher number of leaves and plant height over Kufri Lauvkar both in Gen-0 and Gen-1 seed crops (Table 1).

Total No. of tubers and yield/ha

Number of tubers/ha: In Gen-0 under net house, total tuber number was significantly higher with polythene solarization (2195 thousand/ha) followed by paddy straw mulch and minimum with unsolarized soil (Table 2). Among different treatment combinations, significantly higher total tuber number was reported with polythene solarization in Kufri Chipsona-1 (2398 thousand/ha). In Gen-1 (field conditions), non-significant differences were reported among solarization treatments for total number of tubers, however, highest tuber number was recorded in paddy straw mulch (554 thousand/ha). Among varieties, Kufri Chipsona-1 recorded higher total tuber number in both, Gen-0 and Gen-1 over other two varieties.

Yield/ha: In Gen-0, significantly higher total tuber yield was recorded with polythene solarization (29.33 t/ha) followed by solarization with paddy straw mulch (26.75 t/ha) and unsolarized soil (26.07 t/ha) (Table 2). Iriany *et al.* (2014) reported that black plastic silver mulch gave significantly higher growth and production than straw mulch and no mulch in potato. Significantly higher tuber yield (t/ha) was recorded in Kufri Lauvkar (30.49 t/ha) over Kufri Mohan and Kufri Chipsona-1. Triki (2001) have also reported improvement in the potato yield due to soil solarization. Yield advantage in potato due to solarization varies in different agro-ecological regions as well as among genotypes (Singh *et al.* 2018). Among interactions, no significant differences were recorded for yield/ha.

In Gen-1, significantly higher total tuber weight was

Table 2 Effect of soil solarization and variety on tuber number ('000/ha) and tuber yield (t/ha)

Solarization/ varieties	Tuber number ('000/ha)								Tuber yield (t/ha)							
	Generation -0 (Net house)				Generation -1 (Open field)				Generation -0 (Net house)				Generation -1 (Open field)			
	K. Mohan	K. Chipsona 1	K. Lauvkar	Mean	K. Mohan	K. Chipsona 1	K. Lauvkar	Mean	K. Mohan	K. Chipsona 1	K. Lauvkar	Mean	K. Mohan	K. Chipsona 1	K. Lauvkar	Mean
SSPM	2082	2398	2105	2195	503	587	367	486	28.97	26.62	32.39	29.33	42.00	31.37	23.99	32.45
PSM	1741	1948	2115	1934	602	681	380	554	23.14	24.93	32.17	26.75	51.63	33.82	26.91	37.45
US	2078	1798	1828	1901	496	594	379	490	27.66	23.64	26.90	26.07	39.56	29.67	24.79	31.34
Mean	1967	2048	2016		534	621	375		26.59	25.06	30.49		44.40	31.62	25.23	
CD (P=0.05)																
Solarization (A)		200.3				NS				1.319				3.861		
Variety (B)		NS				43.0				2.484				2.405		
Factor (B) at same level of A		327.6				NS				NS				4.699		
Factor (A) at same level of B		315.7				NS				NS				5.103		

SSPM, Soil solarization with polythene mulch; PSM, Paddy straw mulch and US, Unsolarized soil.

recorded in paddy straw mulch (37.45 t/ha) over polythene solarization (32.45 t/ha) and unsolarized soil (31.34 t/ha). Among varieties Kufri Mohan recorded the significantly higher total tuber weight (44.40 t/ha) over Kufri Chipsona-1 and Kufri Lauvkar (Table 2). Singh (2013) have also reported that black polyethylene mulch recorded significantly highest tuber yield (316.6 q/ha) followed by transparent polyethylene mulch (301.1 q/ha) and no use of mulch resulted in lowest yields. In present study, there is slight increase in the yield in black polythene mulch solarization. Significantly higher yield in paddy straw mulch under field conditions might be due to more availability of nutrients due to decomposition of paddy straw in open field conditions.

Weed population: Under Gen-0 (net house), the number of weeds/M^2 in unsolarized soil was 96 followed by paddy straw mulch 72/M^2 and least in solarization with polythene mulch (51/M^2) resulting in 88.23% and 41.05% reduction in weed population by solarization with polythene and paddy straw mulch respectively over unsolarized plots. Similar trend was reported in Gen-1 in open field, where unsolarized soil recorded 242 weeds/M^2 and soil solarization with polythene mulch recorded 127 weeds/M^2 whereas, paddy straw mulch recorded 175 weeds/M^2 (Table 1). This also resulted in 74.80 and 37.79% reduction in weed population by solarization with polythene and paddy straw mulch respectively. Singh *et al*. (2009) reported reduction in weed population by 96.9% in soil solarization with polythene over control in potato micro-tuber study under net house. Subsequently, Singh *et al.* (2012) have reported that soil solarization significantly reduced weed population by 94.1% compared to the unsolarized soil. Weed numbers were reduced by 86–94%, and weed biomass reduced by 94–99% with solarization treatments compared to the untreated controls (Stapleton *et al.* 2005). Reduction in weed population plays a significant role in lowering multiplication of insect pests and viruses hence expected to reduce spread of virus vectors and viral diseases in seed potato crop. Most weed and pathogen propagules are present in soil in upper 5-10 cm depth. In present study, the temperature raised under polythene mulch up to 43.5 and 46.2^{o}C in Gen-0 (Fig 1) and 46.1 and 51.1^{o}C in Gen-1 (Fig 2) under 5 and 10 cm depth respectively and thus proved beneficial in lowering the weed populations by killing the non-dormant weed seeds and pathogen propagules under both conditions and increasing the yield.

In the present study, solarization influenced the available nutrients, both at planting and harvesting. The weed populations were reduced both under net house (88.23%) and open field conditions (74.80%) by solarization with polythene mulch. Potato yield were highest in polythene solarized soil (29.33 t/ha) in Gen -0 and with paddy straw mulch (37.45 t/ha) in Gen-1 compared to the un-solarized soil.

REFERENCES

Buckseth T and Singh R K. 2018. Hi-tech seed production system. *In* Training manual on "Seed Potato Production". ICAR-Central Potato Research Institute, Shimla & CPRS, Jalandhar April 04-13, pp 8–13.

Horowitz M, Regev Y and Herzlinger G. 1983. Solarization for weed control. *Weed Science* **31**: 170–79.

Iriany A, Soemarno S and Suprayogo D. 2014. Effectivity of mulches and organic matter as an effort of potatoes to adapt with climatic changes. *Journal of Biology, Agriculture and Healthcare* **4**(4): 54-63.

Khan I A, Ullah Z and Daur I 2013. Comparison of different weed control techniques in maize. *Global Journal of Science Frontier Research Agriculture and Veterinary* **13**(4): 13–15.

Krueger R and Mc Sorley R. 2009. Solarization for pest management in Florida. ENY-902, Entomology and Nematology Department, Florida Cooperative Extension Service, IFAS, University of Florida, Gainesville, FL.

Nichols M A. 2005. Aeroponics and potatoes. *Acta Horticulturae* **670**: 201–06.

Patil S S, Kelkar T S and Bhalerao S A. 2013. Mulching: A soil and water conservation practice. *Research Journal of Agriculture and Forestry Sciences* **1**(3): 26–9.

Ramakrishna A, Hoang M T, Suhas P W and Tranh D L. 2006. E□ect of mulch on soil temperature, moisture, weed infestation and yield of groundnut in northern Vietnam. *Field Crops Research* **95**: 115–25.

Ritter E, Angulo P, Riga P, Herrán C, Relloso J and San Jose M. 2001. Comparison of hydroponic and aeroponic systems for the production of potato minitubers. *Potato Research* **44**: 127–35.

Sarkar S and Singh S R. 2007. Interactive effect of tillage depth and mulch on soil temperature, productivity and water use pattern of rainfed barley. *Soil and Tillage Research* **92**: 79–86.

Singh R K, Sharma Jyotsana, Singh G K and Trehan S P. 2009. Effect of soil solarization on multiplication of in-vitro planting materials of potato under field conditions. *Potato Journal* **36**(3-4): 143–8.

Singh R K, Sharma J, Jha S K and Singh A K. 2012. Solarization technique: its use in the multiplication of *in vitro* planting materials. *Current Science* **102**(10): 1433–36.

Singh R K, Buckseth T, Sharma A K, Moudgi V, Chakrabarti S K and Singh A K. 2018. Soil solarization in relation to potato production: A review. *Indian Journal of Agricultural Sciences* **88**(1): 03–09.

Sofi T A, Tewari A K, Razdan V K and Koul V K. 2014. Long term effect of soil solarization on soil properties and cauliflower vigor. *Phytoparasitica* **42**: 1–11.

Stapleton J J, Molinar R H, Lynn-Patterson K, McFeeters S K and Shrestha A. 2005. Soil solarization provides weed control for limited-resource and organic growers in warmer climates. *CalifAgric* **59**: 84–89.

Triki M A, Priou S and Mahjoub M E L. 2001. Effects of soil solarization on soil-borne populations of *Pythium aphanidermatum* and *Fusarium solani* and on the potato crop in Tunisia. *Potato Research* **44**: 271–9.