whereas during November it underpredicted the area of rainfall, except light rain. There are some areas over the southern part of Karnataka where forecast errors were large during October and November. Correlation between observation and forecast is significant, especially for October and November, when significant rainfall activities were present. As expected, the model skill is relatively low for heavy rain cases. With the assimilation of more observations such as AWS and CSIR COMoN data, it is expected that the model skill may improve over those areas.

There is a need to improve forecasts in all aspects of accuracy, lead, resolution and scope (variables). The forecast technology is likely to evolve continuously. Thus, as the user demands grow, it will be necessary and possible to improve and upgrade. Further, such forecasts can be more effective if value-added, such as through agro-advisories and communicated in local language. KSNDMC has developed, and is parallelly testing, interface with various agencies to ensure timely and effective dissemination of the forecasts to the end-users.

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ACKNOWLEDGEMENTS. This project is funded by KSNDMC, Government of Karnataka and supported by CSIR C-MMACS with high-performance computing (HPC) under its Outreach Programme of the Network Project, 'Integrated Analysis for Impact, Mitigation and Sustainability (IAIMS)'. We thank the C-MMACS HPC group for its support. We also thank the Mesoscale and Microscale Meteorology Division at the National Center for Atmospheric Research, USA for access and support of WRF and its 3D-Var assimilation system and the National Centers for Environmental Prediction, USA for the analysis data. The radiosonde data were obtained from the University of Wyoming website. The real-time forecasts were generated and transmitted with the help of the Industrial Partner of C-MMACS, M/S Frontier Pusher.

Received 7 September 2011; revised accepted 13 April 2012

Solarization technique: its use in the multiplication of *in vitro* planting materials

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A field experiment was carried out to evaluate the improvement in the quality and quantity of potato (*Solanum tuberosum* L.) seed using the techniques of soil solarization using six potato cultivars. The soil temperatures increased with the use of polyethylene mulch. It was found to be higher by 10.6°C, 9.4°C, 5.5°C and 3.1°C at depths of 0 cm, 5 cm, 10 cm and 15 cm respectively, compared to the unsolarized soil. The technique of soil solarization increased the available nutrients, viz. NO_3–N, P_2O_5 and K_2O by 17.7%, 63.3% and 27.20% at planting and 16.25%, 21.95% and 14.7% at harvesting respectively. The weed populations were also found to be reduced by 94.7% and its fresh weight by 96.8%. The yields of micro-tuber and mini-tuber produce were significantly higher in solarized plots (248.1 q/ha and 425.9 q/ha respectively) compared to unsolarized plots (188.2 q/ha and 369.7 q/ha respectively).

Keywords: Mulching, soil, solarization, potato, weed.

SOIL solarization is a hydrothermal process which brings about thermal and other physical, chemical and biological changes in the moist soil during and even after mulching[1]. The technique has been variously used in the eradication or reduction of soil pathogen population, weed control, increased growth response, and yield and improvement of quality of the produce[2–5]. In India, potato

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Table 1. Effect of soil solarization on micro-tuber emergence, yield of mini-tuber and rate of multiplication

Variety	Emergence of micro-tubers (%)			Yield of mini-tubers (q/ha)			Rate of multiplication of micro-tubers (tubers/plant)		
	SS	USS	Mean	SS	USS	Mean	SS	USS	Mean
Kufri Ashoka	81.2	78.8	80.00	325.9	229.7	277.8	6.15	6.03	6.09
Kufri Badshah	62.0	67.0	64.50	225.9	166.7	196.3	5.93	5.15	5.54
Kufri Pukhraj	58.5	54.0	56.25	285.2	183.3	234.2	5.44	5.04	5.24
Kufri Surya	62.3	52.0	57.15	226.6	182.6	204.6	5.2	5.0	5.10
Kufri Jyoti	44.5	41.6	43.05	219.4	190.0	204.7	5.1	5.2	5.15
Kufri Chandramukhi	40.6	33.5	37.05	205.6	176.9	191.2	5.4	5.3	5.35
Mean	58.2	54.8	56.33	248.1	188.2	218.1	5.54	5.29	5.41
LSD (0.05): Cultivar		16.3			29.4			0.79	
SS/USS		NS			19.6			NS	
Interaction axb		NS			40			NS	

SS, Solarized soil; USS, Unsolarized soil; NS, Non-significant.

is being grown as a commercial crop in almost all the states under diversified agro-climatic conditions and ranks fifth in area as well as production in the world. With continuous increase in the area under potato cultivation, a proportional increase in seed requirement is envisaged in the future. Therefore, in order to have virus-free, healthy seed stocks of potato in the country, the integration of rapid multiplication technique is highly desirable and urgently needed to fulfil domestic requirements and export. Keeping in view the above facts, an experiment was conducted to study the response of soil solarization on weeds, soil pathogens and productivity of micro- and mini-tuber crop.

A field experiment was carried out at the Central Potato Research Station, Jalandhar, for two crop seasons. The micro- and mini-tubers of six cultivars (Table 1) were raised to produce mini-tubers and breeder's seed of potato respectively, in solarized and unsolarized plots. Raised beds of size 1.5 m × 1.5 m for micro-tubers in an insect-proof net-house (net used from planting to harvesting), and 3 m × 2.4 m for mini-tubers in the open fields, were prepared prior to the solarization and pre-irrigated 48 h before mulching. Beds for solarization treatment were then covered with 50–75 μm thick, transparent linear, low-density polyethylene sheets for 4 weeks in June. The sheets were spread by taking care that there was no air trapped inside them, and then the borders of the sheets were buried about half foot under the soil to secure the sheets in place. The unsolarized beds were left bare during the period. Treatments were replicated thrice in randomized block design. Mercury thermometers were used to record the 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). The weekly maximum ambient temperatures during the period of solarization (15 May–15 June) were 38.5°C, 39.3°C, 40.3°C and 37.2°C in the first, second, third and fourth week respectively, with a mean of 38.8°C. At the end of solarization period, the polyethylene sheets were removed from the soil surface.

The micro-tubers were collected from the Department of Biotechnology, Central Potato Research Institute, Shimla, where these are produced under aseptic conditions through meristematic culture. Pre-sprouted (100 nos) micro-tubers of each cultivar were planted on each bed considering row–row and plant–plant spacing of 15 cm in each case. After planting, the beds were irrigated using sprinkler irrigation at an interval of 1–2 days up to earthing up. Thereafter, the interval of sprinkler irrigation was increased to 5–6 days and furrow irrigation was started at an interval of 10–12 days. The mini-tubers (60 nos) of each cultivar were planted on each bed with a row–row spacing of 60 cm, whereas plant–plant spacing was maintained at 20 cm on the ridges. All recommended cultural practices and plant protection measures were followed for both the crops. Soil samples taken at planting and at harvest were analysed for nitrate nitrogen (NO_3–N), available P_2O_5 and K_2O following standard procedures[6]. Haulms were pulled according to the recommended seed plot technique. Data were recorded on various parameters and statistically analysed. The rate of multiplication of the micro-tubers and mini-tubers was computed as follows:

Number of tubers/plant = Total number of tubers on each beds/number of plants.

Emergence of micro-tubers and mini-tubers was not significantly affected by solarization (Table 1). Emergence of micro-tuber crop was 58.2% and 54.8% in solarized and unsolarized soil treatments respectively, whereas in mini-tuber crop it was 100% in both the treatments. However, the varietal differences in emergence of micro-tuber crop were significantly higher in Kufri Ashoka (80.5%) and lowest (37.05%) in Kufri Chandramukhi. On an average 48% of the yield of mini-tubers was recorded due to soil

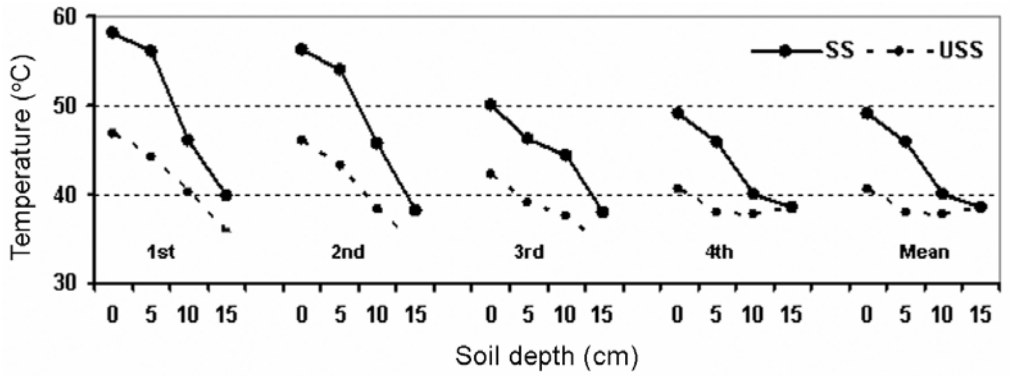

Figure 1. Weekly mean maximum soil temperature (°C) in solarized and unsolarized soil at different soil depths in the four (first to fourth) weeks of June.

Table 2. Soil nutrients as influenced by soil solarization

Nutrient	Available nutrients in soil (in ppm) – Planting – Solarized	Planting – Unsolarized	Harvesting – Solarized	Harvesting – Unsolarized	Percentage of reduction in available nutrients in soil from planting to harvesting – Solarized	Unsolarized
NO_3–N	312	195	118.0	101.5	62.17	47.90
K_2O	186	114	100	82.0	46.20	28.10
P_2O_5	89	70	39.0	34.0	56.18	51.40

solarization. The mean yield of mini-tuber Kufri Ashoka (277.8 q/ha) was highest and of Kufri Chandramukhi was the least (191.24 q/ha). The highest yield of Kufri Ashoka was mainly due to early and higher emergence of micro-tubers and early duration cultivars (80–85 days) compared to Kufri Badshah (120–130 days), a late bulking variety[7]. Significant increase (64.2%) in micro-tuber produce of Kufri Badshah due to solarization has been reported earlier[8]. Soil solarization did not significantly affect the rate of multiplication of micro-tuber produce, which was highest in Kufri Ashoka (6.09) and least in Kufri Surya (5.10).

The average weekly maximum temperature at all the soil depths was higher in solarized plots compared to unsolarized plots (Figure 1). The mean maximum soil temperatures recorded under the plastic mulch were 53.3°C, 50.5°C, 44.0°C and 38.6°C at the soil depths of 0 cm, 5 cm, 10 cm and 15 cm respectively. The soil temperatures under solarization were found to be higher by 10.6°C, 9.4°C, 5.5°C and 3.1°C at the respective depths compared to the unsolarized soil. Solarization has the potential to raise the soil temperature under the tarp by 8–12°C over unfilmed control[9,10]. The higher temperature under the mulch can be attributed to the maximum transmittance of incoming short-wave radiation.

Soil nutrients (N, P and K) were influenced by soil solarization both at the time of planting as well as harvesting (Table 2). The increase in available nutrients was 17.7% N, 63.2% P and 27.14% K at planting and 16.25% N, 21.9% P and 14.7% K at harvesting due to solarization. The increase in N and P due to soil solarization has also been reported by earlier investigators[2]. The reduction in available K_2O (64.4%) and NO_3–N (29.79%) was higher in solarized soil as compared to unsolarized soil during the potato growth period. This could partially be due to increase in potash solubilizers and nitrifying microorganisms in the solarized soil, as solarization increases thermo-tolerant microfauna in the soil[2], most of which are beneficial – the bioagents, nutrient solubilizers and nitrifiers[11]. This would result in more numbers and bulking of potato tubers and with higher tuber yield.

Production of breeder's seed from mini-tuber crop was significantly affected with solarization in all the six tested varieties. An average increase in yield due to soil solarization was 15.20% (Table 3) and the highest increase of 21.6% was recorded in Kufri Ashoka. A significant increase in the yield of potato mini-tuber crop in solarized plots has been reported[2,7], which recorded a significant increase in potato tuber yield with solarization under the conventional method of propagation. The rate of multiplication of mini-tuber produce in solarized and unsolarized soil did not differ significantly among cultivars. The mean rate of multiplication was significantly highest in Kufri Ashoka (11.41 times) followed closely by Kufri Pukhraj (10.45), whereas it was significantly lowest in Kufri Badshah (8.46), Kufri Chandramukhi (8.35), Kufri Surya (8.10) and Kufri Jyoti (7.70).

Table 3. Effect of soil solarization on mini-tuber emergence, yield of breeder's seed and rate of multiplication

Variety	Emergence of mini-tubers (%)			Yield of breeder's seed (q/ha)			Rate of multiplication of mini-tubers (tubers/plant)		
	SS	USS	Mean	SS	USS	Mean	SS	USS	Mean
Kufri Ashoka	100	100	100	432.9	355.9	392.4	12.3	10.51	11.51
Kufri Badshah	100	100	100	439.2	376.9	405.3	8.58	8.34	8.46
Kufri Pukhraj	100	100	100	503.7	469.9	486.6	10.30	10.61	10.41
Kufri Surya	100	100	100	406.8	354.6	380.7	8.20	8.00	8.10
Kufri Jyoti	100	100	100	385.2	339.6	362.4	7.90	7.50	7.70
Kufri Chandramukhi	100	100	100	390.8	321.5	356.2	8.40	8.30	8.35
Mean	100	100	100	425.9	369.7	397.3	9.28	8.87	9.09
LSD (0.05): (a) Cultivar		NS			34.20			1.35	
(b) SS/USS		NS			41.5			NS	
Interaction a × b		NS			NS			NS	

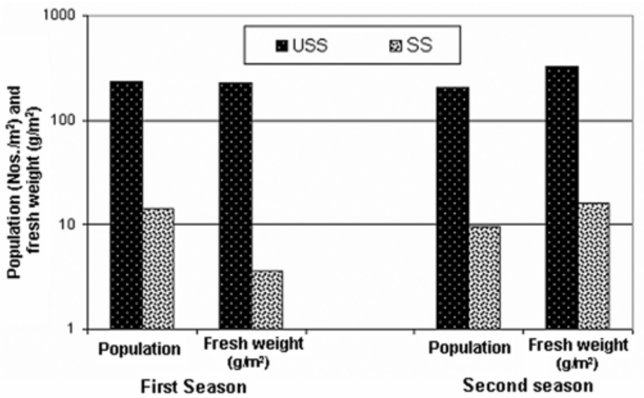

Figure 2. Weed population (no./m^2) and fresh weight (g/m^2) in solarized and unsolarized soil during the first and second season.

Soil solarization significantly reduced weed population by 94.1% and fresh weight of weeds by 98.4% in the first season compared to the unsolarized soil. The corresponding values in the second season were 95.3% and 95.2% respectively (Figure 2). All weeds except, *Cyperus rotundus* were effectively controlled by solarization. The reduction in weed population plays a significant role in lowering multiplication of insect pests and viruses, as these are the alternate hosts. Irrigation prior to solarization results in breaking the dormancy of the weeds and pathogen propagules present in the soil, most of them in upper 5–10 cm depth. The increased temperature under the tarp was sufficient to kill the non-dormant weed seeds and pathogen propagules, thus reducing their population. This is also in agreement with earlier studies[8,12].

Thus mulching with polyethylene increased the soil temperatures at all depths compared to the unsolarized soil. Solarization increased the available nutrients, both at planting and harvesting. The weed populations reduced and the yields of micro-tuber and mini-tuber produce were higher compared to the unsolarized soil.

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Received 6 September 2011; revised accepted 12 April 2012