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Effect of soil solarization on physio chemical properties of soil under protected cultivation

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Abstract
Solarization may bring complex changes in physicochemical properties, like organic carbon, nitrogen, phosphorus, potassium, pH, EC etc. that affects soil micro flora and soil micro fauna. The study conducted under different polyhouse conditions for 45 days, revealed that solarization results in slight change in the pH and EC of the soil, the status of nitrogen, potassium and phosphorus were raised substantially whereas there was a reduction in the status of organic carbon, the maximum decrease in organic carbon of 19.6 per cent was recorded in controlled polyhouse. The amount of phosphorus increased in solarized soils with maximum increase of 26.1 per cent in open field solarized soil. Amount of potassium increased by about 30.6 per cent in open field solarised conditions. Nitrogen increased enormously from 62.72 to 100.32 kg/ha in controlled polyhouse.

Keywords: Protected cultivation, Soil solarization, mulching and Physio chemical properties

1. Introduction
Soil solarization is an environment friendly method of using solar radiation for controlling soil borne plant pathogens by mulching the soil and covering it with tarp, usually with a transparent polyethylene cover for four weeks or more when irradiation and temperatures are high, to increase the maximal temperatures to a level lethal to pest. This effect is successful especially to control those plant pathogens and pests that are heat sensible and unable to survive at temperatures above 37–40°C. Furthermore, soil pasteurization by solar heating gives positive effects against a broad number of seed weeds affecting crops cultivation, it is also very effective in managing the soil inhabitant insect pests, weeds, nematodes, plant pathogenic fungi and bacteria and also results in an increased growth response (IGR) of plants (Katan, 1981) [6].

Protected structures on one hand provide ambient growing conditions to the plant, on the other hand this condition is congenial to the plant pathogens also. Solarization appears to be of major use in greenhouse culture. The ability of greenhouse operators to close up greenhouses during the hot summer months allows higher solarization temperatures than achievable in treatment of open fields.

Solarization can cause complex changes in physicochemical and biological properties such as, increasing the availability of mineral nutrients and soluble organic matter that affects soil micro flora and soil micro fauna population with high influences on the enzyme systems linked with the respiratory process. Environmental factors such as soil temperature and soil moisture are known to have pronounced influence on the dynamics of soil respiration (Scopa and Dumontet, 2007) [9]. Lot of work have been done on soil solarization in open condition but under protected cultivation detailed scientific information is lacking in India, though it is being practiced by most of the growers. In view of this, the present experiments were conducted to study the effect of soil solarization on soil physiochemical properties under different growing conditions.

2. Materials and methods
Experiments were carried out at Precision Farming Development Centre (PFDC) of G.B. Pant University of Agriculture and Technology, Pantnagar.

Solarization Technique
Mulching was done in open field condition as well as inside the polyhouses. Two polyhouse structures i.e. controlled and naturally ventilated were used.

The length and width of polyhouse was 30 feet and 12 feet respectively having side height was 8 feet and the central height of the polyhouse was 11 feet. The cladding material was of 150 GSM, UV stabilised and cross laminated polyfilm. Naturally ventilated polyhouse was made up of bamboo structure. Controlled polyhouse was made up of GI structure and mechanically ventilated to maintain desired temperature and moisture conditions. Before mulching the soil with polyethylene sheet, pre-irrigation was done to ensure enough moisture during the period of solarization. After that it was covered with 25 µm thick transparent polyethylene sheet to maintain air tight condition. Firm polyethylene mulch was insured to prevent any leakage of heated air, gases, moisture etc., as are essential for successful solarization. After covering the plots with polyethylene sheets, the edges of polyethylene sheet were sealed in furrows and buried in the soil. Care was also taken to avoid damage to polyethylene sheets. The damage of any kind was repaired immediately. Solarization was done for 43 days between 11 June to 23 July, 2011.

Soil Sampling

Soil samples were taken from each condition at pre designated dates particularly before and after solarization for detailed analysis. Before analysis, the samples were sieved to remove plant debris, thereafter it was air dried for 18-25 hrs. For study of physicochemical properties it was stored in plastic bags at low temperature and subsequently analysed in the Department of Soil Science.

2.1 Estimation of soil parameters

Soils from each treatment were taken for the estimation of different soil parameters viz., available nitrogen, phosphorous, potassium, organic carbon content, electrical conductivity, and pH.

Electrical conductivity

Electrical conductivity is measured using electrical conductivity meter which works on principle of Wheatstone bridge.

Soil pH

A soil-water suspension was prepared in the ratio of 1:2.5 (10 g soil with 25 ml of distilled water) and pH was measured with the help of pH meter (Chopra and Kanwar, 1982) [3].

Organic Carbon

Soil organic carbon content was determined by Rapid Titration Method (Walkley and Black, 1934) [12]. In this method two gram of soil was oxidized with a mixture of potassium dichromate and concentrated sulphuric acid utilizing the heat of dilution of sulphuric acid. Unused potassium dichromate was back-titrated with ferrous ammonium sulphate in presence of diphenylamine indicator.

Available nitrogen

Available nitrogen was determined using Kjeldahl method (Kjeldahl, 1883) [7] where soil sample was digested to convert organic nitrogen into ammonical nitrogen and ammonical nitrogen is estimated by acid base titration using bromocresol green indicator.

Available phosphorus

Available phosphorus is determined by employing 0.5 M $NaHCO_3$ of pH 8.5 as extracting reagent (Olsen *et al.* 1954) [8].

Available potassium

1M NH_4OAc at pH 7 extract of soil was used to determine the available potassium in soil (Haby *et al.* 1990) [5]. The extraction is carried out by shaking and supernatant liquid was separated by filtration. Potassium is estimated by flame photometer.

3. Results and Discussion

Effect on soil pH

To study whether cations which are held by adsorption on the surface of soil colloids get disturbed when soil is subjected to repeated heating and cooling in different conditions during solarization. The pH was measured both before and after solarization. It is evident from the data (Table.1) that there is no effect of polyethylene mulching on the pH status of soil. The initial pH remained almost as such in open field conditions. There was slight change in pH under polyhouse conditions. Under controlled polyhouse it was 7.6 and under naturally ventilated it was 7.5, after solarization it became 7.5 and 7.3 respectively. It showed that due to solarization it moved towards neutral. Similar observations have been made by Chen and Katan (1980) [2] and Stapleton *et al.* (1985) [11].

Effect on electrical conductivity of soil

Results pertaining to effect of soil solarization on electrical conductivity of soil are given in Table 1. The observations clearly indicate that solarization had no significant effect on electrical conductivity of the soil as its values were almost similar in most of conditions. Except openfield solarized conditions, EC slightly got down in rest of conditions. Bavel (1950) [1] reported that steam sterilization brought instability on soil aggregates due to wetting and drying of soil and thus changing electron exchange capacity.

Organic carbon

Study of soil solarization on the status of organic carbon in pre and post solarized soil (Table-1) revealed that there was a slight decrease from 0.66 to 0.53 per cent in solarized soil, from 0.67 to 0.59 in naturally ventilated, 0.50 to 0.53 in open field solarized and 0.54 to 0.49 in non solarized soils. When the per cent change in its status over initial amount was computed, it was observed that maximum decrease of 19.6 per cent was recorded in controlled polyhouse followed by 11.9 per cent in naturally ventilated and 3.92 per cent in open field solarized and non solarized conditions. The results clearly indicate that solarization reduced the amount of organic carbon in soil to various extents. This indicates that there might be an increase in nitrogen status, infact NO_3^--N and NH_4^+-N, which may result from decomposition of organic matter (Chen and Katan, 1980 [2]; Stapleton *et al.* 1985 [11]) were both found in higher concentration in the solarized soils.

Phosphorus

Effect of soil solarization on the status of phosphorus revealed that there is an increase in the status of phosphorus in solarized soils (table-1). The amount of phosphorus increased from 72 to 80.66 (Kg ha^{-1}) in controlled polyhouse, 76.33 to 84 in naturally ventilated polyhouse, 65.28 to 82.32 in open field solarized soil. However there was only slight increase in phosphorus content in non solarized soil. per cent change in its status over initial amount was found to be increased, though marginally ranging from 9 per cent to 20 per cent in solarized soils. The maximum increase of 20 per cent was observed in open field solarized soil while there was no considerable change in phosphorus content in non solarized soils. Similar observations have been made by Chen and Katan (1980) [2]; Stapleton *et al.* (1985) [11] and Esfahani (1991) [4] that solarization increases the amount of phosphorus marginally.

Potassium

Similar to phosphorus, the amount of potassium increased from 166.35 to 187.33 in controlled polyhouse, from 192 to 212 in semi controlled, 150 to 205 in outside solarized soils, whereas it was almost same i.e. 157 in unsolarized soils. per cent increase over that of original amount was observed that mulching of the soil for 43 days increased the amount of potassium by about 11per cent to 23 per cent. Thus the results of present investigation pertaining to rise in amount of phosphorus are in confirmity to findings of several researchers (Chen and Katan, 1980 [2]; Stapleton *et al.* 1985 [11] and Esfahani, 1991 [4]).

Nitrogen

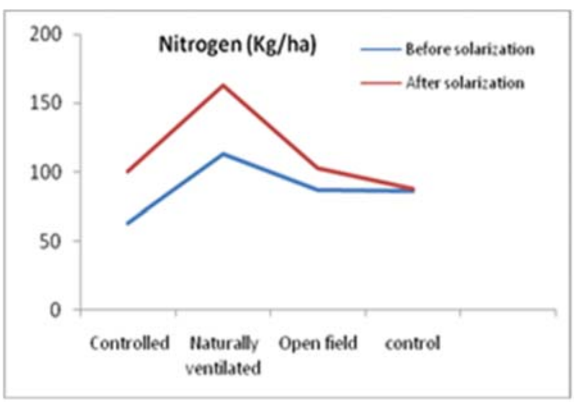
From data obtained (Table-1), it is evident that there was only slight increase in nitrogen content of non solarized soil i.e. from 85.80 to 87.26 whereas nitrogen content increased enormously from 67.72 to 100.32 in controlled polyhouse, from 112.89 to 163.07 in naturally ventilated and from 86.87 to 102.17 kg ha^{-1} in open field solarized condition. When the per cent change in its status over initial amount was taken into consideration, it was observed that maximum increase of 59.9 per cent was found in controlled conditions followed by 44.4 per cent in naturally ventilated polyhouse, 17.6 per cent in open field solarized and 2.89 per cent in non solarized soils. Similar results were recorded by Stapleton *et al.* (1997 [10], 1985 [11]) and Wier *et al.* (1986) [13] that nitrogen appears to be one of the major elements whose availability is most consistently increased in solarized soils.

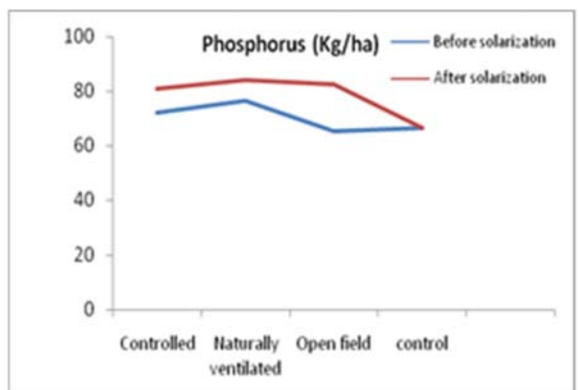
Table 1: Effect of soil solarization on physiochemical properties of soil

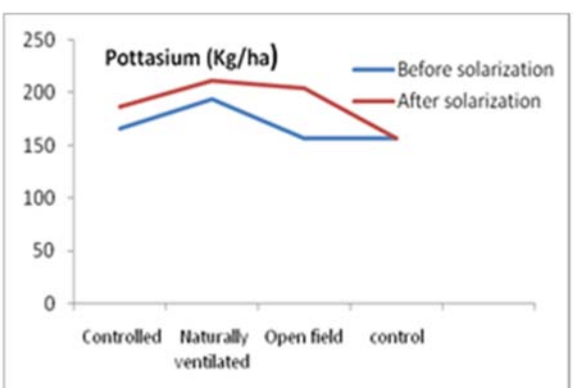
Treatment	Before solarisation						After solarization					
	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	Organic Carbon (Kg/ha)	pH	EC (ds/m)	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	Organic carbon (Kg/ha)	pH	EC (ds/m)
Solarization under Controlled polyhouse	62.72	72	166.33	0.66	7.6	0.29	100.32 *(59.94)	80.66 (12.02)	187.33 (12.75)	0.53 (19.69)	7.5	0.28
Solarization under Naturally ventilated polyhouse	112.89	76.33	194	0.67	7.5	0.26	163.07 (44.45)	84.00 (10.04)	212.00 (9.27)	0.59 (11.94)	7.3	0.24
Solarization under Open field condition	86.87	65.28	156.96	0.50	7.4	0.25	102.17 (17.61)	82.34 (26.13)	205.00 (30.60)	0.48 (4.00)	7.4	0.26
control	85.80	66.33	157	0.51	7.5	0.25	87.26 (1.70)	66.66 (0.49)	157.33 (0.21)	0.49 (3.92)	7.5	0.24

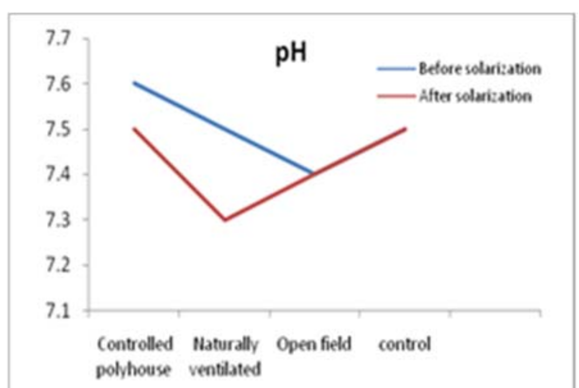
CD at 5% 1.59 (a) 1.95 (b) 1.12 (c) 3.90 (a x b) 2.25 (b x c) 2.75 (c x a) 5.51 (a x b x c)
CV: 5.64

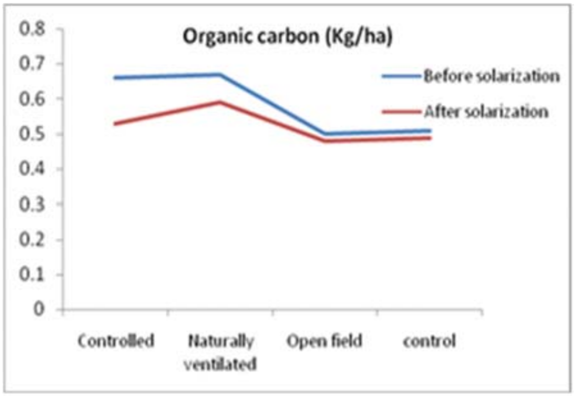
a: Treatments b: Physiochemical properties c: Conditions *per cent increase/ decrease over initial content











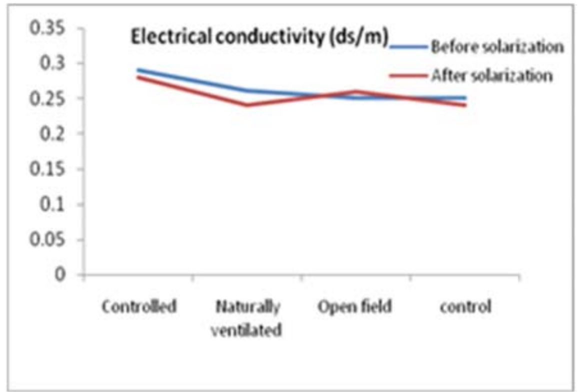


Fig 1: Effect of soil solarization conditions on physio chemical activities of soil

4. Conclusion

Solarization brings complex changes in physicochemical and biological properties like, increasing the availability of mineral nutrients and soluble organic matter that affects soil micro flora and soil micro fauna. Soil mulching was found more effective in protected conditions as compared to open field conditions without affecting the soil physiochemical properties adversely. There is slight change in the pH and EC of the soil, the status of nitrogen, potassium and phosphorus were raised substantially whereas status of organic carbon was found to be reduced.

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