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Soil solarization an effective management practice on weed management and yield of palak (*Beta vulgaris* var. *bengalensis*)

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ABSTRACT

Soil solarization is a non-chemical approach which can be performed by heating the soil during the summer months through various methods. It is an effective method of controlling soil borne pathogens, pests and weeds become inactivated by high temperature and excessive moisture during the hot season. Therefore an investigation was conducted to study the soil solaraization an effective management practice on weed management and yield of palak (*Beta vulgaris* var. *bengalensis*) was carried at Annamalai Univesity, Annamalai Nagar, Chidambaram in Cuddalore District, Tamil Nadu. The experiment was laid out in a Randomized Block Design with seven treatments in three replications consisting of soil management treatments *viz.*, fallow summer ploughing one time in 30 and 45 days, summer ploughing 2 times in 30 and 45 days, application of transparent polyethylene film of 0.05 mm thick for 45 days and biodegradeable polyethylene film for 45 days and compared with a control. The yield and weed components *viz.*, number of leaves per plant, leaf weight per plant, leaf area per plant, yield of greens per plant, yield of greens per plot and yield of greens per hectare and weed parameters *viz.*, weed count, weed control efficiency, weed biomass and weed control index were recorded at the time of harvest and were analysed. The results revealed that application of transparent polyethylene sheet significantly recorded the highest weed control index and improved yield parameters in Palak.

***Keywords*:** Soil solarization, palak, weed and yield parameters, *Beta vulgaris*

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1. INTRODUCTION

Palak (*Beta vulgaris* var. *bengalensis*) is one of the most popular leafy vegetables of tropical and subtropical region and grown widely. In India, palak is commonly cultivated as a cool season vegetable and its tender soft succulent leaves are used as vegetable. It is a rich source of vitamins like A, C and minerals.

Weeds are major problem in cultivation of palak which accounted for greater yield loss. Weeds were considered the most important pest group in a survey of organic vegetable growers (Glanessi & Reigner, 2007). Worldwide consumption of herbicides represents 47.5% of the 2 million tons of pesticide consumed each year. However, the heavy use of herbicides has given rise to serious environmental and public health problems. Weed scientists are now facing new challenges, particularly in the light of the emergence of weeds resistant to herbicides and concerns and questions about herbicide residues in food, soil, and groundwater-atmosphere. Soil solarization have been successfully tried and were found to be effective and safe methods to control weeds. (Abouziena *et al*., 2015).

Soil solarisation is a non-chemical method of suppresses weed growth and pest development, leading to improvement of crop yield. The method has been commonly applied to control weeds in a tropical environment with characteristically high and constant daily temperature.

Soil solarization has already been implemented in commercial production systems, and has a great potential for organic produce growers, where efficient control methods for weeds and soil-borne pathogens are almost nonexistent. This technology originated during the 1970s that was intended for soil disinfestations by means of solar energy. At the time, the deleterious effect of high temperatures on management of soil-borne pathogens and weeds were already known, but heat treatment of soils was not widely implemented due to economic considerations and practicality issues. It is also a well-known practice that was utilized to increase the productivity of crops by manipulating the environment to enhance plant growth and development.

The application of new biodegradable plastics in agriculture calls for improved testing approaches to assure their environmental safety and full biodegradation (≥90%) of biodegradable plastics has been reported and it prevents accumulation in soil.

Hence an experiment was conducted to study the effect of off management practices on growth and yield and weed management of Palak with the objectives of:

i) To study the effect of soil solarization practices on yield of palak
ii) To study the effect of soil solarization practices on weed management of palak

2. MATERIALS AND METHODS

A field experiment was carried out at Department of Horticulture, Annamalai University, Annamalai Nagar and Chidambaram in Cuddalore District of Tamil Nadu, India. The experiment was laid out in a Randomized Block Design with three replications. The greens of Palak (*Beta vulgaris* var. *bengalensis*) popularly grown in this region were utilized for the present study (Rajinder, *et al.* 2013; Sumati, *et al.* 2018).

2. 1. Treatment details

S.NO	Treatments
T_1	**Control**
T_2	**Summer ploughing 1 time (30 days)**
T_3	**Summer ploughing 2 times (30 days)**
T_4	**Summer ploughing 1 time (45 days)**
T_5	**Summer ploughing 2 times (45 days)**
T_6	**Application of transparent polythene sheet of 0.05 mm thickness**
T_7	**Application of biodegradable polythene sheet of 0.05 mm thickness**

2. 2. Solarization management

The experimental field was divided into seven equal strips of which, one was maintained as fallow (Control) and the others were subjected to off-season land management treatments in six different methods. Immediately after receiving the summer showers, the solarization works were started in strips (strips allotted for summer ploughing 1 and 2 times) by ploughing one time in one strip and in the another strip for two times at 15 days intervals for 30 and 45 days respectively, so as to bring the soil to a fine tilth and more aerated. Then the solarization treatment was done for 45 days in May-June by covering with transparent polyethylene film of 0.05 mm thick in one strip and with biodegradable polyethylene film in another strip. The polyethylene films should be tarped over the levelled soil and the sides were buried into the soil to maintain air tight condition.

2. 3. Summer ploughing

Summer ploughing the traditional method of off-season land management is defined as ploughing the land twice at an interval of 15 days, coinciding with peak summer helped in weed control in succeeding crops and also by depleting the soil seed bank of the predominant weeds.

2. 4. Transparent Polyethylene plastic mulch

Plastic films can contain additives that improve their properties for use in solarization. Additives include pigments, heat-retaining substances, wetting agents, ultraviolet stabilizers and photodegradable or biodegradable additives (Brown *et al*., 1991; Stevens *et al*., 1991). Rubin and Benjamin (1984) studied the solar heating of the soil and revealed that the polyethylene sheets of 0.04 to 0.05 mm thick increased the soil temperature from 10 °C to 18 °C in wet soils.

2. 5. Biodegradable plastic mulch

Suitable alternative methods for the disposal of plastic films include the use of biodegradable materials (Kyrikou and Briassoulis, 2007). At the end of their life, biodegradable materials can be integrated directly into the soil where microflora transforms them into carbon dioxide or methane, water, and biomass. Hence biodegradable materials do not produce wastes and does not require disposal, they could represent a sustainable ecological alternative to low-density polyethylene films (Kapanen *et al.* 2008).

2. 6. Preparation of beds and sowing of seeds

After the completion of the solarization period the experimental area was ploughed thoroughly to bring it to fine tilth and the field was divided in to beds of 1m X 1m size. At the time of last ploughing the required quantity of farm yard manure was incorporated. The required quantity of seed balls of palak variety. All green was sown in the treated plots after sowing irrigations were carried out as per the requirement of crop. The recommended intercultural operations were carried out as per the requirement of the crop. The crop was harvested at periodical intervals.

2. 7. Observations recorded

Observations were recorded on randomly selected six plants in each treatment. The observations on number of leaves per plant, leaf area, yield of greens per plant, yield of greens per plot and yield of greens per hectare, weed count, weed control efficiency, weed biomass and weed control index were recorded and statistically analysed by statistically analysis system SAS (1999) .

3. RESEARCH FINDINGS AND DISCUSSION

The results of the present investigation revealed that the highest number of leaves per leaf area, weed count, weed biomass and weed control index recorded significant influence due to application of transparent polyethylene sheet significantly increased the yield and weed parameters.

3. 1. Yield parameters

The yield in palak is a function of highest number of leaves per plant and leaf weight per plant. In the present study highest number of leaves per plant (20.16,21.11 and 28.13 cm respectively at 15,30 and 45 DAS) and leaf weight per plant (5.01, 5.35 and 6.01g respectively at 15,30 and 30 DAS), leaf area (51.08, 62.10 and 69.43 cm^2 respectively at 15,30 and 30 DAS). This was followed by the treatment where biodegradble polyethylene film was applied where the number of leaves of 4.21, 7.25 and 9.21 respectively at 15, 30 and 30 DAS, leaf weight (3.13, 3.67 and 3.86 g respectively 15,30 and 30 DAS), leaf area (23.15, 39.02 and 54.12 cm^2 respectively 15,30 and 30 DAS).

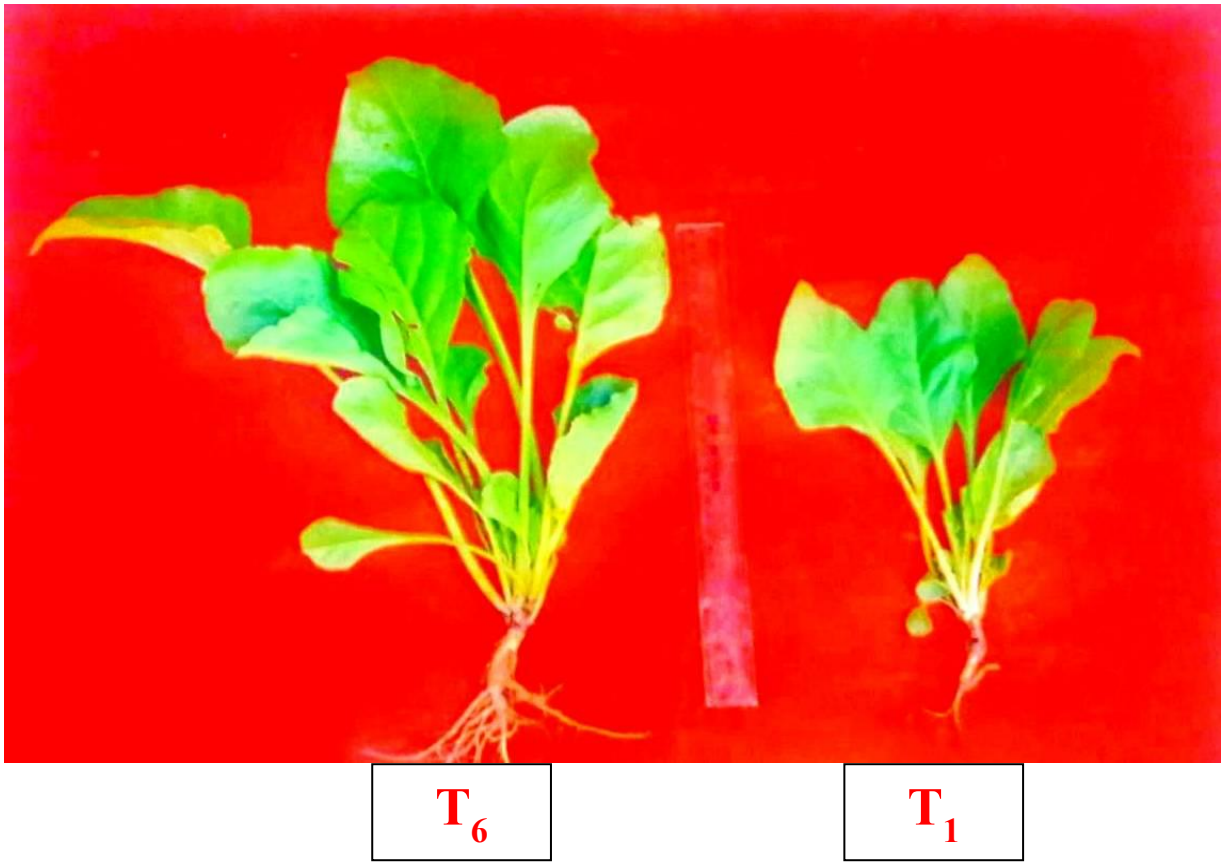
The lowest number of leaves per plant (4.21 7.25 and 9.21 respectively at 15,30 and 45 DAS) and leaf weight per plant (3.13, 3.67 and 3.86 g respectively 15,30 and 30 DAS) leaf area (23.15, 39.02 and 54.12 cm^2) were recorded in the treatment of solarization with transparent polyethylene film of 0.05 mm thick. Similar conclusions were derived by Hasing *et al*. (2004)

reported that soil solarization increased the yield of lettuce by enhancing as evidenced by higher head weight. Soil solarisation improved cucumber plant growth and fruit yield, the fruit yield was 133% to 258% higher in the solarized as compared with the nonsolarized treatment (Ashrafi *et al*., 2008).

The observations on palak yield per plant (184.08 g), yield per plot (2.20 kg) and yield per hectare (21.20 t) were recorded the highest due to the effect of transparent polyethylene film of 0.05 mm thick. This was followed by the treatment where biodegradable polyethylene film was applied which yield per plant (170.87g), yield per plot (2.08 kg) and yield per hectare (20.08t). The lowest yield per plant (130.12 g), yield per plot (2.08 kg) and yield per hectare (16.10 t) were recorded in T_6.

Similar results were supported by the findings of Aggarwal Sonia *et al.* (2003). Lambarado *et al*. (2012) reported by solarization, a treatment which consists of covering a wet soil with a thin transparent plastic film during the hot season, resulting in capture of solar energy which ultimately raises the soil temperature sufficiently to kill many invertebrate pests, weed seeds and microbes (Mauromicale *et al*., 2005). Further, solarization is less liable to create a biological vacuum, and furthermore, appears to stimulate root growth and crop yield.

3. 2. Comparison of best treatment and control in *Beta vulgaris* var. *bengalensis*



T_1 - Control
T_6 - Application of transparent polyethylene sheet

Table 1. Effect of soil solarization management on yield parameters of Palak.

Treatments	Number of leaves per plant			Leaf weight per plant (g^{-1})			Leaf area (cm^2)		
	15 DAS	30DAS	45DAS	15DAS	30DAS	45DAS	15 DAS	30DAS	45DAS
T_1 - Control	4.21	7.25	9.21	3.13	3.67	3.86	23.15	39.02	54.12
T_2 - Summer ploughing 1 time (30 days)	6.14	8.12	11.04	3.45	4.01	4.09	27.19	41.23	56.18
T_3 - Summer ploughing 2 times (30 days)	8.21	11.05	14.11	3.71	4.29	4.37	34.11	43.11	59.16
T_4 - Summer ploughing 1 time (45 days)	11.64	15.01	17.16	3.98	4.38	4.49	39.54	47.08	60.41
T_5 - Summer ploughing 2 times (45 days)	14.24	17.21	23.15	4.05	4.41	4.53	42.35	54.05	63.92
T_6 - Application of transparent polyethylene sheet	20.16	21.11	28.13	5.01	5.35	6.01	51.08	62.10	69.43
T_6 - Application of bioplastic polyethylene	17.22	19.02	26.04	4.95	5.01	5.21	48.13	58.13	65.25
SE.d	0.27	0.39	0.65	0.07	0.09	0.11	0.21	0.27	0.33
CD (p = 0.05)	0.59	0.87	0.61	0.14	0.18	0.22	0.42	0.54	0.66

Table 2. Effect of soil solarization management on yield parameters of Palak

Treatments	Yield of greens g, $plant^{-1}$	Yield of greens Kg, $plot^{-1}$	Yield of greens $t\text{-}^{ha}$
T_1 - Control	130.12	1.61	16.10
T_2 - Summer ploughing 1 time (30 days)	138.09	1.69	16.90

T_3 - Summer ploughing 2 times (30 days)	144.15	1.73	17.30
T_4 - Summer ploughing 1 time (45 days)	150.17	1.84	18.40
T_5 - Summer ploughing 2 times (45 days)	162.11	1.93	19.30
T_6 - Application of transparent polyethylene sheet	184.08	2.20	21.20
T_6 - Application of bioplastic polyethylene	170.87	2.08	20.08
SE.d	1.60	0.01	0.17
CD (p = 0.05)	3.20	0.03	0.33

3. 3. Weed parameters

Table 3. Effect of soil solarization management on weed population (m^2) of Palak

Treatments	*** Monocots**		*** Dicots**		
	Cynodon dactylon	***Cyperus rotundus***	***Trianthema portulacastrum***	***Cleome viscose***	***Echino chloacrusgalli***
T_1 - Control	5.48 (30.03)	4.82 (23.23)	5.63 (31.69)	4.39 (19.27)	12.04 (144.96)
T_2 - Summer ploughing 1 time (30 days)	5.24 (27.46)	4.60 (21.16)	5.10 (26.01)	4.17 (17.38)	8.87 (78.67)
T_3 - Summer ploughing 2 times (30 days)	5.20 (27.04)	4.45 (19.80)	4.85 (23.52)	4.08 (16.64)	7.64 (58.36)
T_4 - Summer ploughing 1 time (45 days)	5.12 (26.22)	4.23 (17.89)	4.52 (20.43)	3.87 (14.97)	6.51 (42.38)
T_5 - Summer ploughing 2 times (45 days)	4.73 (22.37)	4.08 (16.64)	4.10 (16.81)	3.49 (12.18)	5.49 (30.14)
T_6 - Application of transparent polyethylene sheet	2.94 (8.64)	2.52 (6.35)	2.36 (5.56)	2.12 (4.49)	2.24 (5.01)
T_6 - Application of bioplastic polyethylene	3.92 (15.36)	3.86 (14.89)	3.75 (14.06)	3.11 (9.67)	4.41 (19.41)

S.Ed	0.04	0.03	0.06	0.05	0.24
C.D (p = 0.05)	0.08	0.06	0.12	0.10	0.12

* Values are square root transformed and those in parenthesis indicate original

One of the objectives in using soil solarization for weed control can be dated to the ancient Indian civilization that utilized sun radiation to apply heat treatment for weed seeds (Gamliel and Katan, 2012). It was found to be very effective for the control of weeds.

Weed flora in the experimental field were monocots *viz.*, *Cynodon dactylon* and *Cyperus rotundus*, dicots *viz.*, *Trianthema portulacastrum, Cleome viscose* Linn *and Echino chloacrusgalli.* It was clear that the major effect of solarization was upon those propagules that were in the initial process of germination while the transparent polyethylene covering was in place. Solarization produced two different complementary effects like foliar scorching of emerged plants under plastic cover and decreased weed emergence after removing the plastic sheets.

This residual effect on weeds is considered as the principal benefit of solarization. In the present study, solarization with transparent polyethylene film of 0.05 mm thick resulted in lowest count of monocots weeds (5.46 no.m^2) and dicots (6.72 no.m^2) was recorded in T_6, highest weed count of monocots weeds (10.30 no.m^2) and dicots (22.06 no.m^2) was recorded in T_1, whereas the lowest weed control efficiency monocots (10.30) and dicots (22.06), was recorded in T_6 and highest weed control efficiency monocots (46.99) and dicots (69.53) was recorded in T_1. Similar finding was reported by Yanyan Dai *et al.* (2016). The reason for decrease of weed count could be attributed by root branching and fresh weight, rhizosphere microflora and yield of collards were negatively correlated with increased by soil solarization.

Table 4. Effect of soil solarization management on weed parameters of Palak

Treatments	Weed control efficiency		**Weed biomass (gm^{-2})		*Weed control index (%)
	Monocots	**Dicots**	**Monocots**	**Dicots**	
T_1 - Control	10.30	22.06	22.67 (513.92)	30.12 (907.21)	-
T_2 - Summer ploughing 1 time (30 days)	4.46	17.76	20.15 (406.02)	28.23 (796.93)	62..48 (53.84)
T_3 - Summer ploughing 2 times (30 days)	6.31	24.88	18.23 (332.33)	26.18 (685.39)	79.64 (62.49)
T_4 - Summer ploughing 1 time (45 days)	9.22	32.45	16.91 (285.94)	23.41 (548.02)	60.71 (51.18)
T_5 - Summer ploughing 2 times (45 days)	14.46	40.70	15.67 (245.54)	20.17 (83.72)	96.32 (75.91)
T_6 - Application of transparent polyethylene sheet	46.99	69.53	9.10 (82.81)	9.15 (83.72)	82.12 (70.87)

T_6 - Application of bioplastic polyethylene	24.46	48.91	12.13 (147.13)	12.05 (145.20)	90.16 (73.19)
SE.d	0.05	0.06	0.04	0.09	1.06
CD(0.05)	0.09	0.12	0.08	0.18	2.12

* Figures in parentheses indicates arc-sine transformed values
** Values are square root transformed and those in parenthesis indicate original

The effect of solarization treatments in reducing the weed biomass was almost similar to that in reducing weed count. In the present study also observation on weed biomass was the least monocots (9.10 gm^{-2}) and dicots (9.15 gm^{-2}) in transparent polyethylene film of 0.05 mm thick for 40 days and the highest in fallow monocots (22.67 gm^{-2}) and dicots (30.12 gm^{-2}). Similar findings were reported by Singh *et al*. (2004) in soybean. The specific environmental conditions such as light, temperature, carbon-dioxide, oxygen and other volatile compounds in the soil controls the process of weed seed germination Rao (2000) has pointed out that total weed emergence was reduced by 97% one week after removal of plastic sheets and up to 77% for the season. Solarization for a period of 5 weeks may be adequate for controlling most summer and winter annual weeds, while a period of at least 5 months is required for such perennial weeds. Vito *et al.* (2000) have reported that soil solarization for a 6-week period effectively controlled both nematodes and weeds, and consequently increased marketable carrot yield compared to a nonsolarized one.

There was a considerable increase in the weed control index of solaraization management treatments. In comparison to the fallow, the weed control index achieved (82.12 %) by solarizing the field with transparent polyethylene film of 0.05 mm thick was remarkably higher. Weed emergence after solarization to a greater extent is the function of weed seed tolerance to solar heating. Similar findings were reported by Ali *et al*., 2015. The possible reason for decreased weed level might be due to transparent polythene mulch increased the soil temperatures, inhibit photosynthesis, killing weeds during crop development. The initiative of using soil solarization to control weeds started after its effects on organisms other than soil-borne pathogens became evident.

4. CONCLUSION

Based on the present investigation, among the various treatments of soil solaraization practices application of transparent polyethylene sheet recorded the highest yield and weed control parameters in Palak.

References

[1] Abouziena, H. F.; Radwan, S. M.; Eldabaa, M. A. T. Comparison of potato yield, quality and weed control obtained with different plastic mulch colours. *Middle East J. Appl. Sci.* 5, 2, 374-382, 2015.

[2] Aggarwal Sonia, B.N. Kalra and J.N. Raina. 2003. Effect of mulches on soil hydrothermal regimes, weed incidence, yield and quality of ginger. *J. Indian Soc. Soil Sci.* 51: 65-67

[3] Ali A. Bajwa, Gulshan Mahajan, and Bhagirath S. Chauhan 2015. Nonconventional Weed Management Strategies for Modern Agriculture. Weed Science, 63(4):723-747.

[4] Ashrafi ZY, Alizadeh HM and Sadeghi S (2008). Effect of soil solarization on the control of Egyptian broomrape (Orobanche aegyptiaca) and yield improvement of cucumber (Cucumis sativus) grown in greenhouse. *Bulgarian J. Agric. Sci.* 14(6): 583-591

[5] Brown, J. E., C. Stevens, V. A. Khan, G. J. Hochmuth, W. E. Splittstoesser, D. M. Granberry and B. C. Early. 1991. Improvement of plastic technology for soil solarization, in Soil solarization: Proceedings of the first conference on soil solarization, Amman, Jordan (DeVay, J. E., J. J. Stapleton, and C. L. Elmore, Eds.). *FAO plant production and protection paper* 109: 277-296

[6] Gamliel A and Katan J (2012) Soil solarization: Theory and Practice. American Phytopathological Society Press, St. Paul, MN USA pp. 1-266.

[7] Gianessi, L. P.; Reigner, N. P. Review: the value of herbicides in U.S. Crop Production. *Weed Technol.* 21, 2, 559-566, 2007.

[8] Hasing JE, Motsenbocker CE and Monlezun CJ (2004). Agroeconomic effect of soil solarization on fall-planted lettuce (Lactuca sativa). *Scientia Horticulturae* 101(3): 223-233

[9] Kapanen A, Schettini E, Vox G, Itavaara M (2008). Performance and environmental impact of biodegradable films in agriculture: a field study on protected cultivation. *J Polym Environ* 16(2):109-122

[10] Kyrikou I, Briassoulis D (2007) Biodegradation of agricultural plastic films: a critical review. *J Polym Environ* 15(2): 125-150

[11] Lombardo, S. A.M.G. Longo, A. Lo Monaco, G. Mauromicale 2012. The effect of soil solarization and fumigation on pests and yields in greenhouse tomatoes. *Crop Protection* 37 (2012) 59e64

[12] Mauromicale, G. et al. Soil solarization, a nonchemical method to control branched broomrape (Orobanche ramosa) and improve the yield of greenhouse tomato. *Weed Sci.* 53, 6, p. 877-883, 2005.

[13] Rao, S. Principles of weed science. 2 Ed. New York: Science Publishers, 2000. 526 p.

[14] Rubin, B. and A. Benjamin. 1984. Solar heating of the soil: Improvement of the environmental factors in the weed control process. *Weed Sci.* 32: 138-142

[15] Singh, V.P., Anil Dixit, J.S. Mishra and N.T. Yaduraju. 2004. Effect of period of soil solarization and weed-control measures on weed growth and productivity of soybean (Glycine max). *Indian J. Agric. Sci.* 74 (6): 324-328

[16] Vito, M. D. et al. Effect of soil solarization and low doses fumigants control of the root-knot nematode Meloidogyne incognita. *Acta Hortic.* 532, 1, p. 171-173, 2000.

[17] Yanyan Dai, Masateru Senge, Kohei Yoshiyama, Pengfei Zhang and Fuping Zhang 2016. Influencing factors, effects and development prospect of soil solarisation. *Reviews in Agricultural Science,* 4: 21-35, 2016.

[18] Rajinder Singh, Geeta Bassi and Dilbag Sing. Influence of sowing time and leaf cuttings on the seed yield and quality components of palak (Beta vulgaris var. bengalensis). *Indian Journal of Agricultural Sciences* 83(4) (2013) 410-4

[19] Sumati Narayan, Ajaz Malik, M.I. Makhdoomi, Ambreen Nabi, K. Hussain and F. A. Khan. Influence of Date of Sowing and Number of Cuttings on Leaf Yield and Quality of Seed in Palak (Beta vulgaris var. bangalensis). *Journal of Experimental Agriculture International* 24(3): 1-4, 2018