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EFFECT OF SOLAR HEATING ON VIABILITY OF *Potamogeton crispus* L. TURION BUDS BY TRANSPARENT AND BLACK POLYETHYLENE SHEETS

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ABSTRACT

Dormant propagules (turions) of curlypond weed *Potamogeton crispus* L. are the principal for weed persistence and survival. In Egypt, laboratory(out-doors) and field experiments were carried out at Bahteem during summer months 1999 and 2000,to study the response of turions to solarization (solar heating). Maximum moistened (M) soil temperature under plastic cover (TPES,BPES) and UC at 5 cm depth averaged 63,52 and 40 °C in June, 65,54 and 41°C in July as well as 59,49 and 38 °C in August, respectively. No sprouts of *Potamogeton crispus* L. emerged from turions during solarization.The effect of solar heating decreased with increasing soil depth. Higher temperature as well as solar heating effect was produced by TPES than by BPES. Under Egypt conditions, the effect of solarization on viability of turions took place 3days through out-doors, while under field experiment the effect took place after 5 days. Soil solarization is considered one of the novel,non pollution and non-chemical methods for controlling *Potamogeton crispus* L. turions by using TPES during July and August for 5 days in the small irrigation canals(2 m wide) in Egypt.

Key words: *Potamogeton crispus, solarization.*

1. INTRODUCTION

Perennial terresterial or aquatic weeds are becoming the dominant weed problems of the world (Pietrese 1979). These plants proliferate from dormant buds originating on propagative organs such as rhizomes, tubers, basal-bulbs, roots and turions buried at various depths below the soil surface (Holm *et al.*, 1969, Sculthorpe, 1971 and Holm *et al.*, 1977).

In Egypt, more than 3900 Km of canals and drains are heavily infested by all types of aquatic weeds after the construction of High Dam. These weeds have seriously reduced the hydraulic efficiency of irrigation system and quantities of water are lost (Khattab and El-Gharably 1982&1984).

Submerged aquatic weeds caused hydrological problem in small canals where the excessive growth reduces the rate of water flow and prevents water from reaching the end of the canals (Tackholm 1974, Khattab and El-Gharably 1986). *Potamogeton crispus* L. is a submerged aquatic weed which produces turions and perennate in summer and survive in winter(Waisel 1971, Sastroutomo 1981 and Kunii 1982). Attalla (1985) mentioned that turions of *Potamogeton crispus* L. are the most important propagules which bear 3-13 buds, and the number of turions/m^2 was about 895 turions. This means that reserves of turions in hydrosoil provide a source of turions for persistent weed problems in canals that often require repeated control treatments. Reduction in the number of dormant turions in hydrosoil would correspondingly reduce this plant persistence and its control.

Katan *et al.*, (1976) and others (Horowitz *et al.*, 1983, Kamar *et al.*, 1993 and Yaduraju *et al.*,1999) used soil solarization for controlling soil-borne pests including terrestrial weeds in certain crops. He mentioned that the method is based on mulching or covering of moist soil by transparent polyethylene sheets during the hot season (months June,July and August). Mulching with polyethylene sheets is widely used to increase the soil temperature.

This investigation is an attempt to study the effect of solar heating on the viability of *Potamogeton crispus* L. turion buds by using transparent and black polyethylene sheets to control it in small canals.

2. MATERIALS AND METHODS

Turions of *Potamogeton crispus* L. were collected from a dense stand, which existed in an irrigation canal at the Agricultural Experiment Station at Bahteem, Kalubia Governorate, during May 1999.

Laboratory experiments were conducted during summer months (June,July and August) to measure soil temperature and the effect of solar heating on *Potamogeton crispus* L. buds viability under transparent and black polyethylene sheets. Plastic basins 50x 40x 35 cm were used. Four thermometers were fixed in one side of the basin. The basins were filled with soil to a depth of 20 cm and were divided to 3 groups. In the 1st group, the soil of the basins was adjusted daily to reach the water holding capacity. In the 2nd and 3rd groups, the soil in the basin was covered with 5 and 10 cm tap water.

Each group was covered with either black or transparent polyethylene sheets or left uncovered to serve as controls. The sheet in each treatment was placed on the surface of the soil or water. The basins were left out-doors and exposed to solar heating during the summer months of 1999. Soil temperatures were measured continuously at depths 0,5,10 and 20 cm at 14 p.m. daily in both covered and uncovered treatments. Air temperature was measured daily during June, July and August 1999. In each basin turions were placed on a plastic net at a depth of 5 cm below the soil surface and each treatment was replicated 3 times, after the basins were exposed to the solar heating (sun), 10 turions which carried 69-82 buds were taken from each basin at 16 p.m. for 3 days during July and repeated in August. The treatments were distributed according to a split plot design with 3 replicates of each group of water in soil [water holding capacity, covered with water 5 and 10 cm] as a main plot. The type of sheet(uncovered, black and transparent sheet) was used as subplots.

Field experiment was conducted during 2000 in five canals in July and repeated in August for 5 days to study the effect of solar heating on *Potamogeton crispus* L. buds viability under transparent and black polyethylene sheets in the canal. The length of each canal was 10 m long, 1m wide and 1m height. One thousand turions/canal were placed on plastic nets covered with 5 cm soil. The treatments were arranged in a complete randomized block design.

Treatments were as following:

1-Moistened and uncovered canal.

2-Moistened and covered canal with black polyethylene sheet.

3-Moistened and covered canal with transparent polyethylene sheet.

4-Canal containing about 5 cm water and covered with transparent polyethylene sheet.

5-Canal containing about 10 cm water and covered with transparent polyethylene sheet.

A fixed number of turions *i.e.*200 turions (50 turions as a replicate which carry (319-447 buds) were taken daily for 5 days at 16 p. m. The viability of the turions taken daily from Laboratory or Canals was examined by Benzyladenine (BA) as mentioned by Imam *et al.*,(1983).

Total killed buds =T.B – T. L. B. by BA after solarization .
Total killed buds % was estimated by the following equation:

Total killed buds % = T.K.B /T. B. of turions x100.

Data were statistically analyzed according to Snedecor and Cochran (1972). Means were compared using the Least Significant Difference (L.S.D.) at the level of 5% probability.

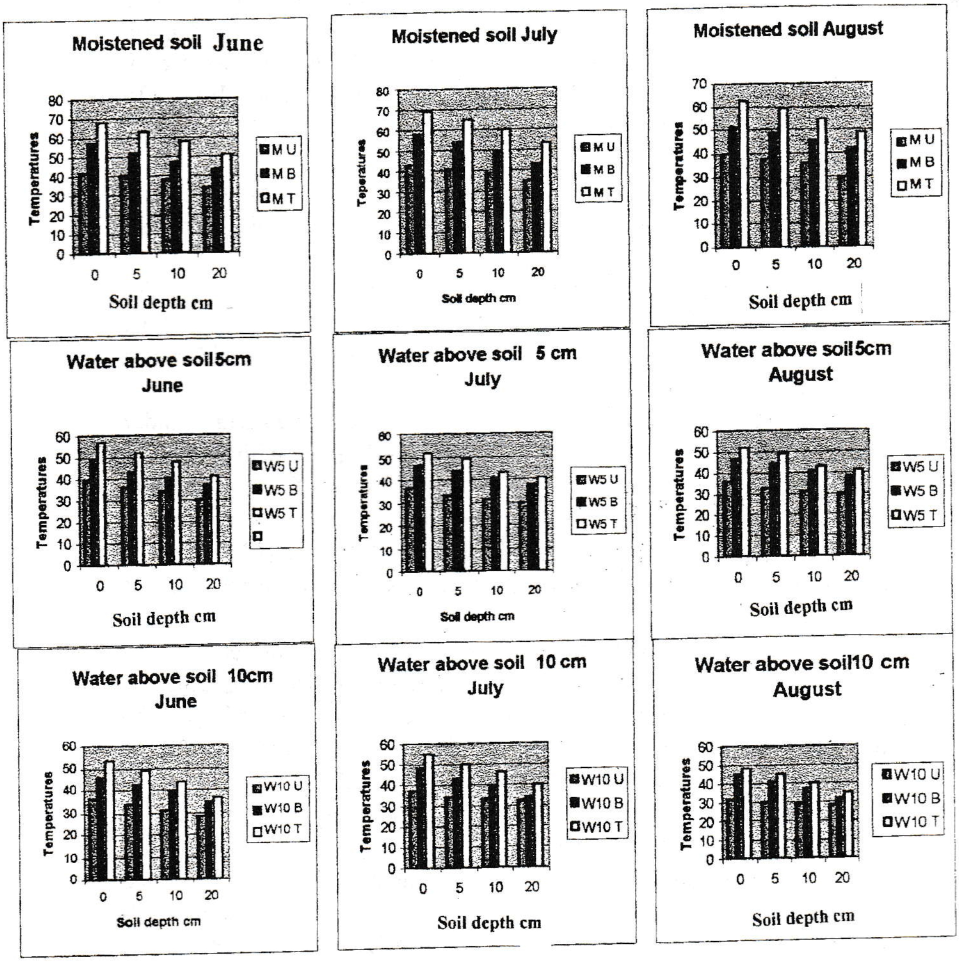
3. RESULTS AND DISCUSSION

Fig. (1) shows the fluctuation of temperature in the different treatments during June, July and August. It is clear that the surface temperatures of moistened (M) and covered soil with transparent, black polyethylene sheet (TPES),(BPES) and uncovered (UC) were 68,57 and 42 °C, respectively. However, the (M) covered with (TPES),(BPES) and (UC) at 5cm depth of the soil, the temperature was 63,52 and 40 °C, respectively.

In treatment which the soil was covered with 5cm tap water (W5) and (TPES),(BPES) and (UC), the temperature at the soil surface was 57, 49 and 39 °C,respectively.

In treatment which the soil was covered with 10cm tap water (W10) and (TPES),(BPES) and (UC), the temperature at the soil surface was 53,46 and 36 °C, respectively. However, the temperature of soil at a depth 5 cm was 49,42 and 34 °C, respectively.

FIG. (1): Maximum soil temperatures recorded during June, July and August 1999.



It is worthy to mention that the temperature of the surface of (M) soil and covered with (TPES) was higher with 26 °C than the (UC-M) soil. However, at 5 cm depth, the difference was 23 °C. These results are due to the high thermal capacity of the soil and poor heat conductivity. These result in a very slow heat penetration and temperature that travels at 2-3cm/hr. These results are in agreement with those obtained by Army and Hudspeth, Jr (1960), Katan *et al.*,(1976), Grinstein *et al.*, (1979), Mahrer (1979) and Katan (1981).

The temperature of the surface of (M) soil and covered soil with (BPES) was higher with 15 °C than the (UC-M) soil. However, at 5 cm depth the difference was 12 °C.

In the treatment (W5), the temperature of the surface under covered soil with (TPES) and (BPES) was higher with 18 and 10 °C, respectively than the (UC) soil. However, at 5cm depth the difference was 16 and 7 °C,respectively.

In the treatment (W10), the temperature of the surface under covered soil with (TPES) and (BPES) was higher with 17 and 10 °C,respectively than the (UC) soil. However,at 5cm depth the difference was 15 and 8 °C, respectively.

Soil temperature at the depth of 10 and 20 cm in (M) and (UC) or covered with (TPES) and (BPES) was less than those recorded at 5cm depth.

Katan (1981) and Horowitz *et al.*, (1983) mentioned that soil temperature under plastic cover is a function of incoming radiation and thermal characteristics of the mulching material and soil. The incoming solar radiation is the main heat source, and transparent covers are more efficient soil heaters than black plastic.

Similar trend in the flactuation of temperature was also recorded during July and August.

Table(1) shows that soil moisture[moistened(M), soil covered with 5 cm water (W5) and soil covered with 10cm water(W10) exposed to solar heating had significant effect on the viability of *Potamogeton crispus* L. turions burried at a depth of 5 cm for 3 days during July and August,1999. (M) gave the highest reduction of turion buds after the 1^{st} ,2^{nd} and 3^{rd} day exposure to solar heating, the values were 45.2,57.2 and 64.2 % in July and 40.4,55.7 and 64.2% in August, respectively. (W5) causing reduction in the same days and the values were 23.5,32.8 and 38.5% in July and 22.2,32.5 and 38%

in August, respectively. The corresponding values of (W10) were 17.9,26.4 and 32.5% in July and 17.5,24.9 and 32.2% in August, respectively. The differences and reduction % among treatments of 1st

Table (1): Average number of total buds,total killed buds and %killed buds as affected by soil moisture (M,W5 andW10) exposed to solar heating on the viability of *Potamogeton crispus* L. turion buds burried at a depth of 5cm for 3 days in July and August 1999.

DAE	Treatment	July 1999			August 1999		
		Total buds	Total killed buds	% Killed buds	Total buds	Total killed buds	% Killed buds
1st day	M	74.7	33.8	45.2	76.0	30.7	40.4
	W5	73.3	17.2	23.5	76.0	16.9	22.2
	W10	73.1	13.1	17.9	74.8	13.1	17.5
	LSD	NS	7.0	----	NS	2.6	---
2nd day	M	74.2	42.4	57.2	77.0	42.9	55.7
	W5	72.8	23.9	32.8	71.9	23.3	32.5
	W10	75.0	19.8	26.4	75.4	18.8	24.9
	LSD	NS	8.8	----	NS	1.7	---
3rd day	M	74.9	48.1	64.2	78.4	50.3	64.2
	W5	75.0	28.9	38.5	73.7	28.0	38.0
	W10	75.7	24.6	32.5	78.6	25.3	32.2
	LSD	NS	10.7	----	NS	2.1	---

day involving M and W5,M and W10 ,W5 andW10 were 16.6(21.7),20.7(27.3) and 4.1(6.6) in July and 13.8(18.2),17.6(22.9) and 3.8 (4.7) in August, espectively. The corresponding values of 2nd day in July and August were significant, where the differences and their reduction % among the same order were 18.5 (24.4),22.6(30.8) and 4.1(6.4) in July and 19.6(23.2),24.1(30.8) and 4.5 (7.6) in August, respectively. The respective values of the 3rd day of soil moisture (M,W5 and W10) in both experiments were significant, where the differences and their reduction % among the same treatments were 19.2 (25.7), 23.5 (31.7) and 4.3 (6) in July and 22.3 (26.2), 25 (31) and 2.7 (4.8) in August, respectively. It is clear that the high temperature injurious effect of the solar heating on the viability of turion buds had increased by increasing the duration of solarization in July and August 1999, *i.e.,* the dead turions % increased by increasing the days of exposure to solarization, where turion buds lost their viability by high temperature 60 °c for 30 minutes (Attalla unpublished). These results are in agreement with those obtained by Army and Hudspeth, Jr (1960), Katan *et al.,* (1976), Grinstein *et al.*,(1979), Mahrer (1979), Katan(1981),Horowitz *et al.*,(1983) and Yaduraju *et al.*, (1999).

Table (2): Average number of total buds,total killed buds and %killed buds as affected by sheet types (UC,BPES and TPES) on the viability of *Potamogeton crispus* L. turion buds burried at a depth of 5 cm for 3 days in July and August 1999.

DAE	Treatment	July 1999			August 1999		
		Total buds	Total killed buds	% Killed buds	Total buds	Total killed buds	% Killed buds
1st day	UC	65.6	1.9	2.9	75.6	1.9	2.5
	BPES	75.9	14.4	19.0	78.3	16.6	21.1
	TPES	73.1	47.8	65.3	72.1	42.2	58.5
	LSD	NS	6.8	---	NS	2.2	---
2nd day	UC	73.6	3.9	5.3	77.9	3.9	5.0
	BPES	74.8	22.4	30.0	74.3	23.9	32.1
	TPES	73.7	59.7	81.1	72.1	57.2	79.4
	LSD	NS	9.9	----	NS	1.7	---
3rd day	UC	74.3	6.0	8.1	75.3	6.7	8.9
	BPES	78.6	29.6	37.6	75.8	30.0	39.6
	TPES	72.7	66.0	90.8	76.2	67.0	87.9
	LSD	NS	8.3	---	NS	0.7	---

Table(2) shows the effect of sheet type on the viability of *Potamogeton crispus* L. turions burried at a depth of 5 cm for 3days during July and August 1999. Sheet type had significant effect on the viability of turions for 1, 2 and 3 days exposure to solar heating when compared with uncovered (uc).

(BPES) caused reduction with the same days and the values were 19,30 and 37.6% in July and 21.1,32.1 and 39.6% in August, respectively. The corresponding values of (UC) were 2.9,5.3 and 8.1% in July and 2.5,5 and 8.9% in August, respectively.

These results are in agreement with those obtained by Army and Hudspeth,Jr (1960), Andrew *et al.*, (1976) , Mahrer (1979) Katan (1981), Mahrer and Katan (1981).

Table (3) shows the interaction effect between soil moisture and sheet type on the viability of turions burred at 5cm during July and August. It is clear from the Table that the injurious effect of solar heating on the viability of turion buds increased with increasing duration of solarization. The percentage of dead buds in the (UC) treatment after the 1st ,2nd and 3rd days during July was 7.9,14.1 and 19.8 respectively. The tendency was also recorded during August. The injurious effect on covered turions with both black and transparent was obvious in treatments (TPES) whether the soil was M or W5 or W10 during July and August.

The data showed also that the percentage of killed buds in the (UC) soil was less than the percentage of killed buds in the covered soil with (TPES) and (BPES) during July and August.

The percentage of killed buds in (M) soil with (TPES) during July and August was 97.3 and 95.2%, respectively. However, in treatments (W5) and (W10) and covered with (TPES),the percentage of killed buds after 3 days exposure was 92 and 83.8% during July and 88.1 and 80.3% during August, respectively.

The percentage of killed buds in (M) soil with (BPES) during July and August was 75.1 and 77.2 % respectively. However, in treatments (W5) and (W10) and covered with (BPES),the percentage of killed buds after 3days exposure was 23.5 and 14.3 % during July and 20.2 and 17.3 % during August respectively.

The percentage of killed buds in the (UC-M) soil was 19.8% during July and 20.1% during August. However, in treatments (W5) and (W10) and without sheet,the percentage of killed buds after 3 days exposure was 4.6 and 0.0 % during July and 5 and 0.0% during August respectively.

These results are in agreement with those obtained by Army and Hudspeth, Jr (1960), Andrew *et al.*, (1976), Mahrer (1979), Katan (1981), Mahrer and Katan (1981), Horowitz *et al.*, (1983), Mahrer *et al.*, (1984) and Yaduraju *et al.*, (1999).

Table (3): Average number of total buds, total killed buds and % killed buds as affected by the interaction between sheet types and soil moisture on the viability of *Potamogeton crispus L.* turion buds burried at a depth of 5 cm for 3 days in July and August 1999.

Month	Treatments	1st day exposure			2nd day exposure			3rd day exposure		
		Total buds	Total killed buds	Killed buds %	Total buds	Total killed buds	Killed buds %	Total buds	Total killed buds	Killed buds %
July 1999	(M)									
	UC	71.7	5.7	7.9	71.0	10.0	14.1	72.3	14.3	19.8
	BPES	79.0	33.0	41.8	77.7	48.7	62.7	79.0	59.3	75.1
	TPES	73.0	62.7	85.9	74.0	68.7	92.8	72.7	70.7	97.3
	(W5)									
	UC	75.0	0.0	0.0	74.0	1.7	2.3	80.0	3.7	4.6
	BPES	71.0	5.3	7.5	71.7	12.7	17.7	75.3	17.7	23.5
	TPES	74.0	46.3	62.6	72.0	57.3	79.6	71.0	65.3	92.0
	(W10)									
	UC	74.0	0.0	0.0	73.0	0.0	0.0	71.0	0.0	0.0
	BPES	78.0	5.0	6.4	63.0	6.0	9.5	81.7	11.7	14.3
	TPES	72.3	34.3	47.4	76.3	53.3	69.8	74.0	62.0	83.8
	LSD	NS	11.7	---	NS	17.2	---	NS	17.3	---
August 1999	(M)									
	UC	78.0	5.7	7.3	74.7	10.0	13.4	79.7	16.0	20.1
	BPES	80.7	36.3	44.8	81.3	54.0	66.4	80.3	62.0	77.2
	TPES	69.0	50.0	72.5	72.0	64.7	89.8	76.7	73.0	95.2
	(W5)									
	UC	73.0	0.0	0.0	77.3	1.7	2.2	80.0	4.0	5.0
	BPES	79.3	7.3	9.2	69.0	10.7	15.5	77.7	15.7	20.2
	TPES	72.0	43.3	60.1	71.7	57.7	80.5	73.0	64.3	88.1
	(W10)									
	UC	72.0	0.0	0.0	75.0	0.0	0.0	70.0	0.0	0.0
	BPES	74.0	6.0	8.1	72.0	7.0	9.7	71.0	12.3	17.3
	TPES	76.3	33.3	43.6	72.3	49.3	68.2	79.3	63.7	80.3
	LSD	NS	3.8	---	NS	3.0	---	NS	1.3	---

Table (4): **Average number of total buds,total killed buds and %killed buds of** *Potamogeton crispus* L. **turion buds as affected by UC,M-BPES,M-TPES,W5-TPES, and W10-TPES in irrigation canals for 5days in July and August 2000.**

Month	Day after exposure	Treatments	UC	M-BPES	M-TPES	W5-TPES	W10-TPES	LSD
July 2000	1st day	T B	365.5	327.5	405.8	391.8	346.3	NS
		T K B	21.5	98.3	284.0	164.5	103.8	21.7
		% K B	5.9	30.0	70.0	42.0	30.0	------
	2nd day	T B	393.0	322.0	435.0	380.0	355.0	NS
		T K B	43.0	164.3	370.0	236.0	184.5	29.4
		% K B	10.9	51.0	85.0	62.0	51.9	-----
	3rd day	TB	335.0	371.0	446.0	421.0	342.0	NS
		TKB	50.0	237.5	405.0	307.5	215.0	23.2
		%KB	14.9	64.0	90.8	72.9	62.9	----
	4th day	TB	396.0	408.0	340.0	336.0	364.0	NS
		TKB	75.0	302.5	320.0	269.5	258.5	17.8
		%KB	18.9	74.1	94.1	80.2	71.0	-----
	5th day	TB	438.0	386.0	355.8	418.8	409.0	NS
		TKB	105.0	312.5	341.5	355.5	319.0	12.8
		%KB	24.0	81.0	96.0	84.9	78.0	------
August 2000	1st day	TB	337.0	355.0	322.0	415.0	386.5	NS
		TKB	16.5	100.0	206.5	161.0	113.5	10.6
		%KB	4.9	28.2	64.1	38.8	29.4	-----
	2nd day	TB	392.0	433.0	348.0	446.0	421.0	NS
		TKB	36.5	207.0	266.0	242.5	202.5	11.2
		%KB	9.3	47.8	76.4	54.4	48.1	-----
	3rd day	TB	366.0	391.0	336.0	399.0	366.0	NS
		TKB	52.0	231.0	286.0	255.0	205.0	7.8
		%KB	14.2	59.1	85.1	63.9	56.0	------
	4th day	TB	310.0	415.0	391.0	441.0	412.0	NS
		TKB	56.5	285.0	358.0	309.0	272.0	9.3
		%KB	18.2	68.7	91.6	70.1	66.0	------
	5th day	TB	338.0	316.3	393.5	436.0	417.0	NS
		TKB	80.5	239.5	370.0	344.5	308.0	9.7
		%KB	23.8	75.7	94.0	79.0	74.9	------

TB=Total Buds. TKB= Total Killed Buds. %KB=% Killed Buds.

Table(4) shows the effect of solar heating for 5 days on the viability of *Potamogeton crispus* L. turions in the small irrigation canal during July and August. Generally the results obtained in the irrigation canal were more or less similar to those obtained from the laboratory basins.

The percentage of killed buds in (M) soil with (TPES) after 5 days exposure was 96 % during July and 94% during August. However, in the treatments (W5) and (W10) and covered with (TPES), the percentage of killed buds after 5days exposure was 84.9 and 78 % during July and 79 and 73.9 % during August, respectively.

The percentage of killed buds in (M) soil with (BPES) after 5 days exposure was 81% during July and 75.7% during August. The percentage of killed buds in (UC-M) soil after 5 days was 24% during July and 23.8 % during August. It is concluded that the results of this investigation showed clearly that *Potamogeton crispus* L. turions could be efficiently controlled in hot summer months (June, July and August) in wet canals using (TPES). Moreover, the injurious effect in (M) soil with (TPES) was higher than in any other treatment using (BPES) or (W5) and (W10) with (TPES) or (UC). The percentage of killed buds increased by increasing the duration of solarization and took place 5 days in the canals. The percentage of killed buds in (M) soil with (TPES) was 70-96% in July and 64.1-94% in August.

Katan (1981), Horowitz *et al.*, 1983 and Yaduraju *et al.*, 1999 mentioned that after covering the soil by plastic sheets, a heat build-up occurs for 2-4 days, (continuous sun shine). They also mentioned that solarization is a method of heating moist soil by covering it with plastic sheets to trap solar radiation. No weeds emerged under the plastic cover during solarization. The heating effect from solarization decreased with soil depth, and the maximum soil temperature under plastic cover was at the 5cm depth where it reduced terrestrial weed buds and weed populations.The response of weed species to solarization differed from 10-28 days where solarization produced effective control of annual weeds.

The soil solarization is considered one of the novel, non-chemical method for controlling aquatic weeds, and being much safer, involving no phytotoxicity or pesticide residues and can be carried out manually it is a non-chemical weed control method. The use of

(TPES) for controlling submerged aquatic weed populations and reduce the weed persistance in small canal is a relatively new technique.

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تأثير الطاقة الشمسية باستخدام الغطاء البلاستيك الأسود و الشفاف على حيوية براعم نبـــات الحريش *Potamogeton crispus* L.

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ملخص

تعتبر أعضاء التكاثر الساكنة (التوريونات) هي أساس التكاثر واســتمرار الحياة للنبات الــائي الحريــش (*Potamogeton crispus* L.) فــى المجــارى المائيه،ونظرا لمشاكله فى قنوات الري فقد إجريت تجربتــان إحداهمـا معمليـه والآخري حقلية (مجرى مائي) خلال عامى١٩٩٩ و ٢٠٠٠. أوضحــت النتــائج المتحصل عليها من التجارب المعملية أن درجة الحرارة العظمى المقاســة علــى عمق ٥سم من التربة الرطبة والمغطاة بالغطاء البلاستيك الشفاف أعلي من درجه الحرارة المقاسة من التربة المغطاة بالغطاء البلاستيك الأســود وغــير المغطــاة وكانت القيــم هــي ٦٣-٥٢-٤٠°م فــى شــهر يونيــو و٦٥-٥٤-٤١°م فــى شهريوليوو٥٩-٤٩-٣٨°م فى شهر أغسطس. أوضحت النتائج أيضا إن درجــه الحرارة تقل مع زيادة عمق التربة. كان تأثير حرارة التشميس على حيوية براعم الحريش أعلي تحت الغطاء الشفاف، وأوضحت النتائج إن التــأثير يحــدث فــى المعمل خلال ثلاثه أيام وفى المجرى المائي خلال خمسة أيــام. تعتــبر عمليــة التشميس باستخدام الغطاء الشفاف خلال شهري يوليو وأغسطس طريقة مقاومـــة حديثــه غــير كيمائيــة نظيفــة ويمكــن مقاومــة النبــات المــائي المغمــور الحريش(*Potamogeton crispus* L.) فى المجارى المائية الصغيرة ذات عرض ٢متر بهذه الطريقة.

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