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PRODUCTIVITY OF SOME CROPS UNDER SOIL SOLARIZATION CONDITIONS IN THE NORTH WESTERN COAST

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Four field experiments were conducted at Desert Research Center farm at Maruyt, north western coastal region during summer and winter seasons of 2002, 2003 and 2004, to study the effect of sheet color (clear and yellow), sheet thickness (150 and 300 µm) and solarization period (0, 4, 6 and 8 weeks) starting on 27th June on broad bean (*Vicia faba* L.) and maize (*Zea mays* L.) growth, productivity and associated weeds as well.

Results indicated that soil solarization using clear polyethylene films in 300 µm thicknesses for 8 weeks incubation period induced significant increase in soil temperature compared with the unsolarized treatment. Soil temperature under the polyethylene sheet showed greater increase at 5 cm than it was at 10 cm depth. Broad bean and maize associated weeds illustrated highly significant growth reduction as a result of the former conditions. Meanwhile, growth characters, yield and components of broad bean and maize represented significant increase resulted from soil solarization using clear polyethylene sheet in 300 µm thicknesses for 8 weeks period.

Solarization treatments affected all the recorded fifteen weed types in different degrees. Annual weeds seem to be mostly affected as a result of solarization treatments.

Keywords: maize, *Zea mays*, broad bean, *Vicia faba*, solarization, polyethylene sheet, incubation period, sheet thickness.

Broad bean is considered to be the major food legume crop in Egypt. It is considered as one of the basic sources of protein in the Egyptian diet with relatively low price. In addition, it has a good role in enriching and improving soil properties of newly reclaimed soils. The Egyptian annual production of broad bean is 400.000 ton in 2004. Likewise, corn is ra[illegible] source of food and nutritional products for people, livestock fe[illegible]d industrial products including ceramics, explosives, construction ma[illegible]s, metal molds, paints, paper goods, textiles, industrial alcohols and et[illegible]l. Egypt is ranked the second between global maize producers. Egyptian m[illegible]ze production increased from 3.35 million ton in 1982 to 7.2 million ton in 2004 (Anonymous, 2004). Increasing such crop production is considered as strategic priority for Egyptian government. This could be attained through both vertical and horizontal extension in the next years. One of the most important challenges that break these extension efforts especially at the horizontal level is soil infestation with weeds; meanwhile using the herbicides is not applicable to save the virgin environment in the newly reclaimed areas from pollution besides saving the natural flora of the area from degradation. Soil solarization may be considered as one of the acceptable ways to solve this problem.

Soil solarization is achieved by mulching moistened soil with plastic sheets during warm summer months thereby raising soil temperature and controlling various weeds and soil-borne pathogens (Jacobsoha *et al.*, 1980)

Using solarization in the newly reclaimed areas as an eco-friend weeds control technology is highly advisable to minimize the number of natural flora plants accompanied with the growing crop as weeds meanwhile keeping the soil capability for natural flora rehabilitation whenever needed.

The explanation of this study is to evaluate soil solarization as an eco-friend weeds control technique in the newly reclaimed soils, and to suggest the most recommended polyethylene sheet color, thickness and period of incubation to be used under north western coastal conditions to produce an appreciated yield of both broad bean and subsequent maize crops.

MATERIALS AND METHODS

Four field experiments were conducted at Desert Research Center experimental farm at Maruyt, north western coastal region during summer and winter seasons of 2002, 2003 and 2004, to evaluate the effect of sheet color (clear and yellow), sheet thickness (150 and 300 μm) and solarization period (0, 4, 6 and 8 weeks) starting on 27th June on broad bean (*Vicia faba* L. var., Giza 776) and the subsequent corn (*Zea mays* L. var., Pioneer- 30 P 9) growth, productivity and their associated weeds.

The high weeds infected calcareous experimental soil was tilled and irrigated until field capacity. During soil preparation calcium super-phosphate (15.5 % P_2O) was added into the soil in the rate of 200 kg/fed along with 20 m^3/fed of compost. Then the soil was divided into stripes having 120m^2 areas per each. The stripes were covered with the polyethylene sheets very closed to the soil surface with keeping their edges anchored in trenches along the strip sides to start the solarization treatments, with keeping some stripes without covering as control. The solarization treatments started on 27th June 2002 and 2003 and ended at 22nd August 2002 and 2003. During these periods in both seasons, daily maximum air temperature above the polyethylene sheets and in the soil under the polyethylene sheets at 5 and 10 cm depth were measured using a digital electronic stem thermometer.

Broad bean (variety Giza 776) agriculture started on the 1st October with no-till after finishing the solarization treatments, at the rate of 50 kg seeds/fed. Nitrogen fertilization was applied in the form of ammonium nitrate (33.5 % N) at the rate of 60 N kg/fed in two equal dosages i.e. after thinning (two plants per hill 21 days after sowing), and after the second irrigation. Also 24 kg K_2O/ fed was added as potassium sulfate (48% K_2O) after thinning.

The subsequent maize crop (variety Pioneer- 30 P9) was sown on 15th April with no-till as well at the rate of 15 kg/ fed. Nitrogen fertilization was applied in the form of ammonium nitrate (33.5 % N) at the rate of 120 N kg/ fed in two equal dosages i.e. after thinning (two plants per hill 21 days after sowing), and after the second irrigation.

Spilt-split plot design in three replicates was used in this experiment, where sheet color occupied the main plots, sheet thickness in the sub-main and incubation period in the sub-sub main plots which was 12 m^2 (3 × 4 m), including 6 ridges at 60 cm in hills at 25 cm distance.

Plant samples were taken at 56 days from sowing date to study some growth characters for broad bean i.e., plant height/ cm, root length/cm, plant fresh and dry weight/g, no. of branches/plant, leaf area/cm^2, total water % , and for maize plants i.e., plant height/ cm, fresh weight/g, dry weight/g, leaf area/cm^2 , total water %. Fourth leaf area of both crops was measured using "Li-3000 A" portable leaf area meter, while total pigments of the same leaves was measured using SPDA-502 leaf chlorophyll meter, then converted into total chlorophyll (a+b) as μ mole m^{-2} following the method published by John *et al.* (1988). Meanwhile, different weed survey was made by collecting weed species associated to each crop three times during each crop life cycle then converted into weeds number/m^2 from each plot during every season for all treatments, then fresh and dry weight of each weed species/m^2 were estimated.

Likewise, yield and its components of both crops were evaluated as biological and seed yield /ton per fed, no. of pods/ plant, no. of seeds/pod and 100 seed weight/g for broad bean, as well as biological and grain yield /ton per fed, no. of ears/ plant, ear length/cm, no. of grains/ear and 100 grain weight/g for maize. These measurements had been taken from 1m^2 sample then converted into fedan area.

Data obtained was exposed to the combined method of statistical analysis of variance described by Steale and Torrie (1960), while Duncans' new multiple range test was used to differentiate between means as described by Duncan (1955).

RESULTS AND DISCUSSION

Effect of Soil Solarization Treatments on Soil Temperature

Generally, both air and soil temperatures were exceeded as a result of soil poly-ethylene sheet mulching during the solarization period (27th June to 22nd August) of both 2002 and 2003 years, as indicated in fig(1).

The average of maximum air temperature during the two seasons was ranged from 30.4 to 47.5 °C. Maximum soil temperatures during the two seasons were always higher in the solarized plots compared with the un-solarized ones. The maximum soil temperature at 5cm depth reached 51 and 46.2°C under clear and yellow sheets respectively, while it was 47.6 and 44°C at 10 cm depth. Meanwhile it didn't exceeded 38°C in the un-solarized plots.

Soil temperatures showed significant increase as a result of elongating incubation period. Likewise, increasing sheet thickness of both clear and yellow sheets led to increase soil temperature. Similar results were obtained by Tamietti and Garibaldi (1989), Alkayssi and Alkaraghouli (1990) and Lalitha *et al.* (2001).

Effect of Sheet Color on Broad Bean and Maize Annual Associated Weeds

Results presented in table (1) indicated that eight species of broad bean associated weeds were recorded; *Malva parviflora, Sonchus oleraceus, Cichorium emdivia, Melilotus indica, Beta vulgaris, Brassica napus, Convolvulus arvensis* and *Medicago polymorpha.* While table (2) represented the eight weed species recorded as associated to maize plant i.e., *Portuloca oleracea, Dactyloctenium aegyptius, Setaria viridis, Chenopodium sp., Convlvus arvensis, Echinochloa colonum, Cynodon dactylon* and *Amaranthus* spp.. Maximum reduction in fresh and dry weights of both associated weeds to broad bean and maize crops (Tables 1 and 2) obtained from using clear poly-ethylene sheet for soil mulching was more than using the yellow one and followed by the un-solarized treatment, only *Portuloca oleracea* associated with maize was not affected by solarization. Similar results were obtained by Alkayssi and Alkaraghouli (1990) who reported that soil temperature which recorded under the clear mulching followed by the yellow one was higher because of the soil heat flux under the poly-ethylene sheet was closely related to the surface energy balance, which decreased from the clear to the yellow mulching one.

TABLE (1). Effect of sheet color on fresh and dry weights of broad bean associated annual weeds (combined analysis of 2003 and 2004 growing seasons).

Sheet color	Broad bean associated weeds							
	Malva parviflora	Sionchus oleraceus	Cichorium endivia	Melilotus indica	Beta vulgaris	Brassica napus	Convolvulus arvensis	Medicago polymorpha
Fresh weight (g/m²)								
Clear	554 1C	17 9C	26 0 C	12 2 C	34 1C	30 3C	21 8 C	11 6 C
Yellow	1332 B	51 7B	73 8 B	38 5 B	104 B	85 7B	65 6 B	28 4 B
Control	6280A	208 A	300 A	150 A	410 A	346 A	250 A	110 A
Dry weight (g/ m²)								
Clear	126 9C	3 6C	15 6C	4 2C	6 8C	10 9C	7 6C	2 8 C
Yellow	346 8B	14 B	13 6B	14 6B	16 2B	25 B	18 4B	6 6 B
Control	1410A	45 A	54 2A	46 4A	65 9A	122 A	72 2A	24 1A

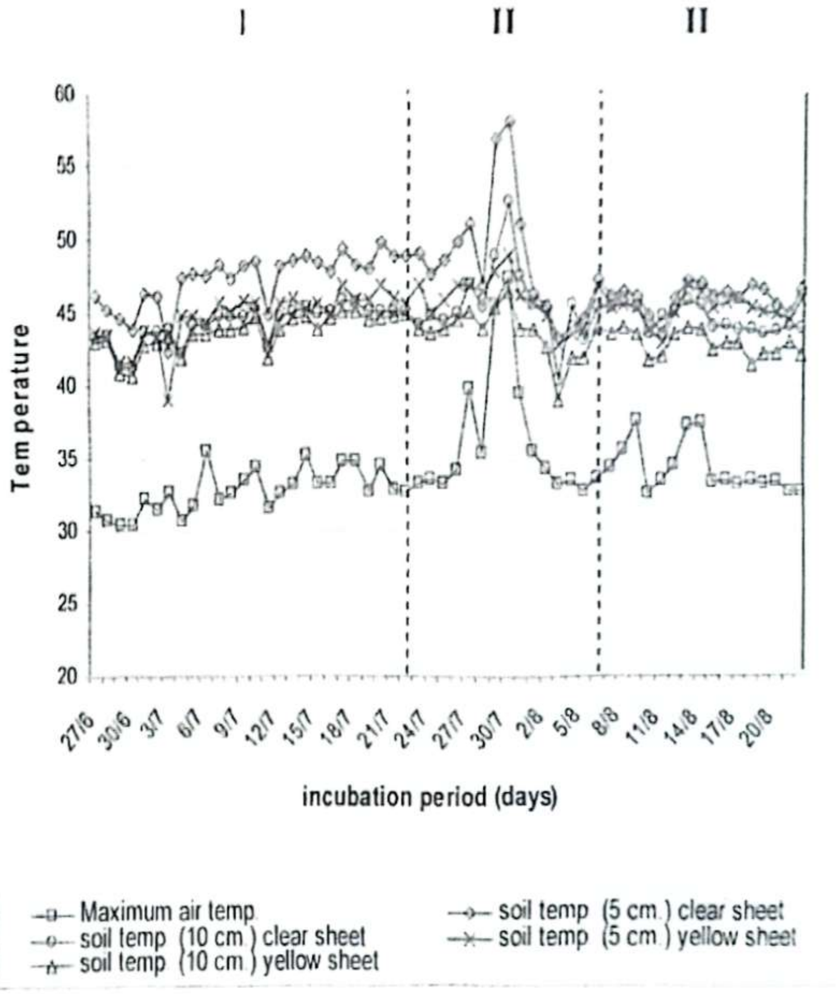
Means having similar letters in the same column are not statistically differed at $P \geq 0.05$.

TABLE (2). Effect of sheet color on fresh and dry weights of maize associated annual weeds (combined analysis of 2003 and 2004 growing seasons).

Sheet color	Maize associated weeds							
	Portuloca oleracea	Dactyloctenium aegyptius	Setaria viridis	Chenopodium sp.	Convlvulus arvensis	Echinochloa colonum	Cynodon dactylon	Amaranthus spp.
Fresh weight (g/m²)								
Clear	851 2C	5 13C	31 5C	29 1C	11 5C	3 47C	4 05C	4 38C
Yellow	1198B	10 8B	73 1B	69 4B	13 6B	7 98B	9 12B	10 1B
Control	1595A	265 A	102 A	242 A	47 1A	27 6A	30 9A	36 0A
Dry weight (g/ m²)								
Clear	109 1C	1 44C	8 58C	7 24C	1 55C	0 85C	1 75C	1 47C
Yellow	151 2B	3 18B	19 6B	17 1B	3 53B	1 88B	4 18B	3 30B
Control	201 A	71 9A	27 2A	60 3A	12 2A	6 60A	14 4A	11 4A

Means having similar letters in the same column are not statistically differed at $P \geq 0.05$.

Fig. (1). Dailly temperature above and under clear and yellow sheet 5 or 10 cm. Soil depth for solarization treatments during the hotsummer days (means at 2002 and 2003 solarizations easons).



I = 28 days incubation period.
I + II = 42 days incubation period.
I + II + III = 56 days incubation period.

Effect of Sheet Color on Growth Characters, Total Pigments, Total Chlorophyll Content, Yield and its Components of Both Broad Bean and Maize Plants

Results in tables (3 and 5) revealed that using the clear sheet for soil mulching was advisable to increase all studied growth characters for both broad bean and maize plants rather than yellow sheet and un-solarized treatments. Increasing soil and air temperatures during solarization led to reduce the associated weeds growth beside enhancing cytokinines (CKs) production and accumulation in the plant roots. therefore increased the plant photosynthetic pigments contents, consequently increase the photosynthesis efficiency as reported by Devlin (1969). In addition, solarizatian also increase soil content of NO_3^- -N and NH_4^+ -N as described by Arora and Yaduraju (1998), and N, P and K as described by Bawazir *et al.*(1995).

TABLE (3). Effect of sheet color on some growth characters, total pigments and chlorophyll content of broad bean (combined analysis of 2003 and 2004 growing seasons).

Sheet color	Studied Characters								
	Plant height /cm	Plant root length /cm	Fresh weight / g	Dry weight /g	No. of bran-ches /plant	Leaf area /cm²	Plant total water %	Total pig-ments /SPDA	Chloro-phyll µ mole m⁻²
Clear	118.4A	14.8 A	312.9A	115.8A	6.8 A	55.2 A	62.6 B	45 A	553.4 A
Yellow	98.9 B	10.4 B	220.3B	77.2 B	3.5 B	40.1 B	64.9 A	39.2 B	440.8 B
Control	85.7 C	8 C	123.3C	40.3 C	2.3 C	24.8 C	68.9 C	32.2 C	327.7 C

Means having similar letters in the same column are not statistically differed at P≥ 0.05.

Enhancing the growth characters plus the significant reduction happened in the associated weeds number as indicated in tables (1and2) decreased the competition between the crop and its associated weeds on the environmental growth factors i.e. water, minerals ..etc which led to increase yield of its components of both broad bean and the followed maize crops (Tables 4 and 6). Perhaps the latter enjoyed the high N soil content coming from soil mulching and nitrogen fixation made by the broad bean itself. Similar results are reported by Abdallah (1999) and Arora and Yaduraju (1998).

TABLE (4). Effect of sheet color on yield and its components of broad bean (combined analysis of 2003 and 2004 growing seasons).

Sheet color	Studied characters				
	Biolo-gical yield (ton/fed)	Seed yield (ton/fed)	No. of pods /plant	No. of seeds /pod	100 seed weight /g
Clear	1.82 A	0.66 A	7.8 A	3.4 A	91.3 A
Yellow	1.19 B	0.35 B	6.3 B	3.1 A	85.8 B
Control	0.99 C	0.16 C	5.2 C	2.9 B	68.96 C

Means having similar letters in the same column are not statistically differed at P≥ 0.05.

TABLE (5). Effect of sheet color on some growth characters, total pigments and chlorophyll content of maize (combined analysis of 2003and 2004 growing seasons).

Sheet color	Studied Characters						
	Plant height /cm	Fresh weight / g	Dry weight /g	Leaf area /cm^2	Total water %	Total pig-ments	Chloro-phyll µ mole m^{-2}
Clear	203.6A	564.3A	88.2 A	360.2 A	88.4 A	68.2 A	1407.6A
Yellow	133.9 B	167.48B	30.7 B	247.9 B	79.5 B	35 B	370.2 B
Control	113.3 C	79.3 C	9.5 C	171.8 C	57.5 C	27 C	248.4 C

Means having similar letters in the same column are not statistically differed at P≥ 0.05.

TABLE (6). Effect of sheet color on yield and its components of maize (combined analysis of 2003and 2004 growing seasons).

Sheet color	Studied characters						
	Biological yield (ton/fed)	Grain yield (ton/fed)	No. of Ears /plant	Ear weight /g	Ear length /cm	No. of grains /ear	100 grain weight /g
Clear	16 A	2.8 A	1.3 A	293.2A	24.3 A	426.5 A	54.9 A
Yellow	11.2 B	1.9 B	1 A	179.6 B	24.9 A	279.3 B	46.3 B
Control	7 C	1.2 C	1 A	110 C	20.6 B	155.3 C	40.9 C

Means having similar letters in the same column are not statistically differed at P≥ 0.05.

Effect of Sheet Thickness on Broad Bean and Maize Annual Associated Weeds

Results in tables (7 and 8) indicated that using the double thickness polyethylene sheet (300 µm) was more effective in reducing the fresh and dry weights of the eight weed species associated with broad bean or the eight weed species associated with the subsequent maize crop rather than using the single polyethylene sheet (150 µm) or the un-solarized treatment. Similar results obtained by Alkayssi and Alkaraghouli (1990) who reported that mulching the soil by double thickness polyethylene sheet (0.1mm) produced higher number of small air bubbles (Tristar) which prevented heat dispersal more efficiently than mulching the soil by single thickness polyethylene sheet (0.05mm), therefore heat temperatures under the former were greater than the latter, this helped in reducing significantly the crop associated weeds number and growth.

TABLE (7). Effect of sheet thickness on fresh and dry weights of broad bean associated annual weeds (combined analysis of 2003and 2004 growing seasons).

Sheet thickness	Broad bean associated weeds							
	Malva parviflora	*Sonchus oleraceus*	*Cichorium endivia*	*Melilotus indica*	*Beta vulgaris*	*Brassica napus*	*Convolvulus arvensis*	*Medicago polymorpha*
Fresh weight (g/m²)								
150µm	1345B	44.3B	62.9B	32.4B	84.2B	74.5B	53.3B	23.8B
300µm	769.3C	25.2C	55.3C	18.3C	54.0C	41.4C	34.1C	16.2C
Control	6280A	208A	300A	150A	410 A	346 A	250 A	110 A
Dry weight (g/ m²)								
150µm	296.7B	12.8B	12.3B	9.53B	15.1B	26.2B	16.7B	5.75B
300µm	174.0C	4.69C	6.92C	9.22C	7.88C	9.43C	9.28C	3.60C
Control	1410A	44.9A	54.2A	46.4A	65.9A	122A	72.2A	24.1A

Means having similar letters in the same column are not statistically differed at P≥ 0.05.

TABLE (8). Effect of sheet thickness on fresh and dry weights of maize associated annual weeds (combined analysis of 2003 and 2004 growing seasons).

Sheet thickness	Maize associated weeds							
	Portulaca oleracea	*Dactyloctenium aegyptius*	*Setaria viridis*	*Chenopodium sp.*	*Convlvulus arvensis*	*Echinochloa colonum*	*Cynodon dactylon*	*Amaranthus spp.*
Fresh weight (g/m²)								
150µm	1128B	9.24 B	62 B	59.6 B	11.7 B	7.07 B	7.87 B	8.82 B
300µm	921 C	6.72 C	42.7 C	38.9 C	13.4 C	4.56 C	5.30 C	5.70 C
Control	1595A	265 A	102 A	242 A	47.1 A	27.6 A	30.9 A	36 A
Dry weight (g/ m²)								
150µm	143.4B	2.76B	16.7B	14.7B	2.98B	1.60B	3.52B	2.90B
300µm	116.9C	1.90C	11.5C	9.7C	2.10C	1.13C	2.41C	1.87C
Control	201A	71.9A	27.2A	60.2A	12.2A	6.60A	14.4A	11.4A

Means having similar letters in the same column are not statistically differed at P≥ 0.05.

Effect of Sheet Thickness on Growth Characters, Total Pigments, Total Chlorophyll Content, Yield and its Components of Both Broad Bean and Maize Plants

Data in tables (9, 10, 11 and 12) showed that using the double thickness polyethylene sheet (300 µm) as a soil mulching for solarization increased significantly all studied growth characters of broad bean and maize crop more than using the single one (150 µm) or the un-solarized treatment, hence significantly increased the yield and its components of broad bean and the subsequent maize crop. This may be due to the rise happened in the soil temperature under the double sheet more than the single one as shown in fig. (1), which led to decrease the associated weeds growth (Tables 7 and 8). This could increase NPK availability in soil besides ammonium (NO_3^- – N) and nitrate (NH_4^+ – N) soil content. In addition, enhancing formation and accumulation of CKs in the roots, as discussed before (Devlin, 1969; Bawazir *et al.*, 1995; Arora and Yaduraju, 1998).

TABLE (9). Effect of sheet thickness on some growth characters, total pigments and chlorophyll content of broad bean (combined analysis of 2003 and 2004 growing seasons).

Sheet thickness	Studied characters								
	Plant height /cm	Root length /cm	Fresh weight / g	Dry weight /g	No. of branches /plant	Leaf area /cm²	Total water %	Total pig-ments	Chlorophyll µ mole m⁻²
150µm	103.4A	11.5 B	194.3B	86.6 B	4 B	43.3B	64 A	40.5B	403.7 B
300µm	98.9 A	13.7A	300.9A	106.4A	6.2 A	51.9A	64.9A	43.7A	528.8 A
Control	85.7 B	8 C	123.3C	40.3 C	2.3 C	24.8C	58.9B	32.2C	327.7 C

Means having similar letters in the same column are not statistically differed at P≥ 0.05.

TABLE (10). Effect of sheet thickness on yield and its components of broad bean (combined analysis of 2003 and 2004 growing seasons).

Sheet thickness	Studied characters				
	Biolo-gical yield (ton/fed)	Seed yield (ton/fed)	No. of pods /plant	No. of seeds /pod	100 seed weight/g
150µm	1.31 B	0.40 B	6.6 B	3.15 A	86.85 B
300µm	1.69 A	0.60 A	7.5 A	3.32 A	90.28 A
Control	0.99 C	0.16 C	5.18 C	2.90 B	68.96 C

Means having similar letters in the same column are not statistically differed at P≥ 0.05.

TABLE (11). Effect of sheet thickness on some growth characters, total pigments and chlorophyll content of maize (combined analysis of 2003 and 2004 growing seasons).

Sheet thickness	Studied characters						
	Plant height /cm	Fresh weight / g	Dry weight /g	Leaf area /cm^2	Total water %	Total pig-ments	Chlorophyll µ mole m^{-2}
150µm	158.2 B	253.5 B	43.4 B	271.8 B	81.5 B	39.4 B	457.9 B
300µm	195.9 A	478.2 A	75.6 A	336.2 A	86.4 A	63.8A	1319.9 A
Control	113.3 C	79.3 C	9.5 C	171.8 C	57.5 C	27 C	248.4 C

Means having similar letters in the same column are not statistically differed at P≥ 0.05.

TABLE (12). Effect of sheet thickness on yield and its components of maize (combined analysis of 2003 and 2004 growing seasons).

Sheet thickness	Studied characters						
	Biological yield (ton/fed)	Grain yield (ton/fed)	No. of Ears /plant	Ear weight /g	Ear length /cm	No. of grains /ear	100 grain weight /g
150µm	12.4 B	2 B	1 A	210.8 B	26.3 B	326 B	47.8 B
300µm	14.9 A	2.6 A	1.3 A	240 A	27.4 A	355.7A	53.4 A
Control	7 C	1.2 C	1 A	110 C	20.6 C	155.3C	39.9 C

Means having similar letters in the same column are not statistically differed at P≥ 0.05.

Effect of Incubation Period on Broad Bean and Maize Annual Associated Weeds

Results presented in tables (13 and 14) illustrate that both fresh and dry weights of the eight weeds species, which associated to each of broad bean and maize, were significantly decreased as a result of increasing the solarization incubation period from 28 , 42 and up till 56 days, respectively if compared to the un-solarized treatment. Maximum reduction of associated weeds fresh and dry weights of the two studied crops was obtained at 56 days incubation period. This may be as a result of increasing the soil temperatures under the poly-ethylene sheet as an upshot of extending the incubation period from 4 to 6 and 8 weeks. Chandrakumar *et al.*(2002) found that soil temperature under the polyethylene sheet increased to reach 50.2°C after 40 days and 67.6 °C after 60 days comparing with the un-solarized treatment 38.6 °C, which led to minimize weeds population.

TABLE (13). Effect of incubation period per week on fresh and dry weights of broad bean associated annual weeds (combined analysis of 2003 and 2004 growing seasons).

Incubation period	Broad bean associated weeds							
	Malva parviflora	*Sonchus oleraceus*	*Cichorium endivia*	*Melilotus indica*	*Beta vulgaris*	*Brassica napus*	*Convolvulus arvensis*	*Medicago polymorpha*
Fresh weight (g/m²)								
4 weeks	1308B	43.3 B	61.1B	32 B	84.9 B	70.4 B	53.6B	24.7 B
6 weeks	1095C	36.1 C	52.6 C	25.5C	72.5 C	61.5 C	45.9C	21.3 C
8 weeks	768 D	25 D	50.9 D	18.6D	49.9 D	42 D	31.5D	14 D
Control	6280A	208 A	300 A	150 A	410 A	347 A	250 A	111 A
Dry weight (g/ m²)								
4 weeks	288.8B	8.08B	11.9B	9.50B	14.3B	21 B	16 B	6.15 B
6 weeks	247.3C	13.5C	9.96C	13.1C	12.0C	17.9C	13.6C	4.50 C
8 weeks	170 D	4.74D	6.91D	5.54D	8.09D	14.7D	9.34D	3.38 D
Control	1410A	44.9A	54.2A	46.4 A	65.9A	121 A	72.2A	24.1 A

Means having similar letters in the same column are not statistically differed at P≥ 0.05.

TABLE (14). Effect of incubation period per week on fresh and dry weights (g/m²) of maize associated annual weeds (Combined analysis of 2003 and 2004 growing seasons).

Incubation period	Maize associated weeds							
	Portuloca oleracea	*Dactyloctenium*	*Setaria viridis*	*Chenopodium*	*Convlvulus arvensis*	*Echinochloa colonum*	*Cynadon dactylon*	*Amaranthus spp.*
Fresh weight (g/m²)								
4 weeks	1208B	10.5B	62.1B	60.3B	20.2B	7 B	81.8B	8.93 B
6 weeks	1121C	7.43C	56.8C	52.4C	10.9C	6.1 C	6.90C	7.71 C
8 weeks	744 D	6.08D	38.0D	35 D	6.90D	4.08D	4.68D	5.15 D
Control	1595A	265 A	102 A	242 A	47.1 A	27.6A	30.9A	36 A
Dry weight (g/ m²)								
4 weeks	155.2B	2.83B	16.9B	14.9B	3.13B	1.71B	3.60B	2.94B
6 weeks	141.4C	2.47C	15.2C	12.9C	2.73C	1.46C	3.06C	2.50B
8 weeks	93.9 D	1.63D	10.2D	8.69D	1.78D	0.98D	2.23D	1.71C
Control	201 A	71.9A	27.2A	60.3A	12.2A	6.60A	14.4A	11.4A

Means having similar letters in the same column are not statistically differed at P 0.05.

Effect of Incubation Period on Growth Characters, Total Pigments, Total Chlorophyll Content, Yield and its Components of Both Broad Bean and Maize Plants

Outcomes in tables (15 and 17) bright up that all studied growth characters of the two crops under investigation were encouraged significantly as a result of extending the solarization incubation periods up to 56 days. These led to increase broad bean productivity as yield and its components as presented in table (16) referring to the decrease in the competition between broad bean and its associated weeds as a result of minimizing weeds growth and population, gained from increasing soil temperature (Table 13) as described by Chandrakumar *et al.* (2002). Meanwhile the increment happened in maize yield and its components (Table 18) came as an additive value from minimizing the associated weeds competition, increasing soil contents of NPK, microbial nitrogen fixation made by the preceded broad bean and the plant growth promoters derived from the rhizobia through broad bean nitrogen fixation pathway (Devlin, 1969; Bawazir *et al.*, 1995; Arora and Yaduraju, 1998; Sivakumar *et al.*, 2001).

TABLE (15). Effect of incubation period per week on some growth characters, total pigments and chlorophyll content of broad bean (combined analysis of 2003 and 2004 growing seasons).

Incubation period	Studied Characters								
	Plant height /cm	Root length /cm	Fresh weight / g	Dry weight /g	No. of bran-ches /plant	Leaf area /cm^2	Total water %	Total pig-ments	Chloro-phyll μ mole m^{-2}
4 weeks	105.7C	11.6 C	239.9C	92.8 C	4.4 C	44.5 C	63.7 C	40.9 C	475.4 C
6 weeks	108.3B	12.4 B	269.8B	95.1 B	4.8 B	46.9 B	64.4 B	42.2 B	497.9 B
8 weeks	112 A	13.8 A	290.1A	101.7A	6.2 A	51.4 A	65.5 A	43.2 A	518.1 A
Control	85.7 D	8 D	123.3D	40.3 D	2.3 D	24.8 D	58.9 D	32.2 D	327.7 D

Means having similar letters in the same column are not statistically differed at P≥ 0.05.

TABLE (16). Effect of incubation period per week on yield and its components of broad bean (combined analysis of 2003 and 2004 growing seasons).

Incubation period	Studied Characters				
	Biological yield (ton/fed)	Seed yield (ton/fed)	No. of pods /plant	No. of seeds /pod	100 seed weight/g
4 weeks	1.33 C	0.42 B	6.62 B	3.18 A	86.3 C
6 weeks	1.52 B	0.54 A	6.95 B	3.23 A	89.3 B
8 weeks	1.67 A	0.55 A	7.61 A	3.29 A	90 A
Control	0.99 D	0.16 C	5.18 C	2.90 B	69 D

Means having similar letters in the same column are not statistically differed at $P \leq 0.05$.

TABLE (17). Effect of incubation period per week on some growth characters, total pigments and chlorophyll content of maize (combined analysis of 2003 and 2004 growing seasons).

Incubation period	Studied Characters						
	Plant height /cm	Fresh weight / g	Dry weight /g	Leaf area /cm^2	Total water %	Total pig-ments	Chloro-phyll µ mole m^{-2}
4 weeks	160.7 C	296.1 C	46.7 C	280.1 C	81.6 C	43.6 C	563.5 C
6 weeks	177.4 B	365.2 B	56.5 B	300.3 B	84.1 B	48.6 B	703.3 B
8 weeks	193.1 A	436.3 A	75.2 A	331.8 A	86.1 A	62.7 A	2437.6 A
Control	113.3 D	79.3 D	9.5 D	171.8 D	57.5 D	27 D	248.4 D

Means having similar letters in the same column are not statistically differed at $P \geq 0.05$.

TABLE (18). Effect of incubation period per week on yield and its components of maize (combined analysis of 2003and 2004 growing seasons).

Incubation period	Studied characters						
	Biological yield (ton/fed)	Grain yield (ton/fed)	No. of ears /plant	Ear weight /g	Ear length /cm	No. of grains /ear	100 grain weight /g
4 weeks	12.1 B	2.1 B	1.1 C	214.8 C	25.1 C	334.7 C	48.4 C
6 weeks	13 B	2.3 B	1.2 B	239.3 B	28.3 B	359.7 B	51 B
8 weeks	15.8 A	2.6 A	1.3 A	260.2 A	27.2 A	375.1 A	52.4 A
Control	7 C	1.2 C	1 D	110 D	20.6 D	155.3 D	39.9 D

Means having similar letters in the same column are not statistically differed at $P \leq 0.05$.

Effect of the First and the Second Order Interactions on Broad Bean and Maize Annual Associated Weeds

Results illustrated in table (19) represent the effect of the first and second order interactions between sheet color, sheet thickness and incubation period on broad bean associated weeds fresh and dry weights, while table (20) was for the following maize crop associated weeds fresh and dry weights. Observations indicated that all the first and second order interactions between the investigated main factors reduced significantly fresh and dry weights of the eight recorded weeds species associated to either broad bean or later maize crop compared with the control treatment. Higher reduction in weeds fresh and dry weights of the two investigated crops were obtained from the interaction between clear and double thickness sheet for 56 days as incubation period. The reduction in the fresh weights of broad bean associated weed species reached 97%, while it was more than 88% for the fresh weights of the maize associated weed species if compared to the un-solarized treatment (control). Similar results were obtained by Bawazir *et al.* (1995), Abdallah (1999) and Sivakumar *et al.* (2001).

Effect of the First and the Second Order Interactions on Growth Characters, Total Pigments, Total Chlorophyll Content, Yield and its Components of Both Broad Bean and Maize Plants

Data in table (19) represent the effect of the first and second order interactions between sheet color, thickness and incubation period on some studied broad bean growth characters, total pigments, total chlorophyll content, while table (20) represent those for the subsequent maize crop. As indicated from the results, all first and second order interactions significantly increased the studied characters of broad bean and maize as well, except the interaction between incubation periods and sheet thickness, which illustrated insignificant effects with the studied characters of broad bean and maize. Similarly, broad bean no. of branches per plant was insignificantly affected under both the interactions of sheet color x thickness and sheet color x incubation period. Also, maize total pigments, chlorophyll, ear length, no. of grains and 100 grain weight were insignificantly affected under the interactions of sheet color x incubation periods and incubation periods x sheet thickness.

TABLE (19). Effect of interaction between sheet color (C), thickness (K) and incubation period (I) on certain parameters of broad bean in addition to its associated weeds (combined analysis of 2003 and 2004 growing seasons).

Certain Parameters	C×K	C×I	I×K	C×K×I
Growth Characters				
Plant height / cm	S	S	NS	S
Root length / cm	S	S	NS	S
Fresh weight / g	S	S	NS	S
Dry weight / g	S	S	NS	S
No of branches per plant	NS	NS	NS	S
Leaf area cm^2	S	S	NS	S
Total water %	S	S	NS	S
Total pigments (SPDA) units	S	S	NS	S
Total chlorophyll μ mol m^{-2}	S	S	NS	S
Yield and its attributes				
Biological yield ton/fed.	S	S	S	S
Seed Yield ton/fed.	S	S	NS	S
No. of pods/plant	S	S	NS	S
No of seeds /pod	S	S	NS	S
100 seed weight/g	S	S	NS	S
Associated Weeds				
Malva parviflora (FW)*	S	S	S	S
Malva parviflora (DW)**	S	S	S	S
Sionchus oleraceus (FW)	S	S	S	S
Sionchus oleraceus (DW)	S	S	S	S
Cichorium endivia (FW)	S	S	S	S
Cichorium endivia (DW)	S	S	S	S
Melilotus indica (FW)	S	S	S	S
Melilotus indica (DW)	S	S	S	S
Beta vulgaris (FW)	S	S	S	S
Beta vulgaris (DW)	S	S	S	S
Brassica napus (FW)	S	S	S	S
Brassica napus (DW)	S	S	S	S
Convolvulus arvensis (FW)	S	S	S	S
Convolvulus arvensis (DW)	S	S	S	S
Medicago polymorpha (FW)	S	S	S	S
Medicago polymorpha (DW)	S	S	S	S

*FW = Fresh weight (g/m^2) , ** DW= Dry weight (g/m^2)

S= significant at $P \geq 0.05$.

NS= not significant at $P > 0.05$.

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Table (20). Effect of interaction between sheet color (C), thickness (K) and incubation period (I) on certain parameters of maize in addition to its associated weeds (combined analysis of 2003 and 2004 growing seasons).

Certain Parameters	C×K	C×I	I×K	C×K×I
Growth Characters				
Plant height / cm	S	NS	NS	S
Fresh weight /g	S	S	NS	S
Dry weight / g	S	S	NS	S
Leaf area / cm^2	S	S	NS	S
Total water %	S	S	NS	S
Total pigments / SPDA	S	NS	NS	S
Chlorophyll / µ mole m^{-2}	S	NS	NS	S
Yield and its attributes				
Biological yield ton/ fed.	S	S	NS	S
Grain yield ton/ fed.	S	S	NS	S
No. of Ears/ Plant	S	S	NS	S
Ear weight / g	S	S	NS	S
Ear length / cm	S	NS	NS	S
No. grains / ear	S	NS	NS	S
100 grain weight /g	S	NS	NS	S
Associated Weeds				
Portuloca oleracea (FW)*	S	S	S	S
Portuloca oleracea (DW)**	S	S	S	S
Dactyloctenium agyptius (FW)	S	S	S	S
Dactyloctenium agyptius (DW)	S	S	S	S
Setaria viridis (FW)	S	S	S	S
Setaria viridis (DW)	S	S	S	S
Chenopodium sp. (FW)	S	S	S	S
Chenopodium sp. (DW)	S	S	S	S
Convolvulus arvensis (FW)	S	S	S	S
Convolvulus arvensis (DW)	S	S	S	S
Echinochloa colonum (FW)	S	S	S	S
Echinochloa colonum (DW)	S	S	S	S
Cynodon dactylon (FW)	S	S	S	S
Cynodon dactylon (DW)	S	S	S	S
Amaranthus spp. (FW)	S	S	S	S
Amaranthus spp. (FW)	S	S	S	S

* FW = Fresh weight (g/m^2) . **DW= Dry weight (g/m^2)
S= significant at $P \geq 0.05$.
NS= not significant at $P \geq 0.05$.

Superior observations were obtained from the treatment consisted of the interaction between clear sheets with double thickness (30 µm) and 56 days incubation period. This can be considered as a result of increasing soil temperature which affected negatively weeds growth, therefore reduced population, so that minimized the competition between the growing crops and its associated weeds. On the other hand, raising soil temperature enriched the NPK soil content, consequently enhanced photosynthetic pigments accumulation, accordingly encourage photosynthesis efficiency, which led to increase broad bean productivity. In respect to the subsequent maize crop, it enjoyed all the improvements happened in the soil during broad bean growing period plus the high nitrogen content made by the broad bean rhizobia , besides the growth promoters derived from *Rhizopium sp.* as reported by Devlin (1969), Bawazir *et al.*(1995), Arora and Yaduraju (1998) and Abdallah (1999).

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إنتاجية بعض المحاصيل تحت ظروف التعقيم الشمسي بالساحل الشمالي الغربي

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أقيمت أربعة تجارب حقلية بمحطة بحوث مريوط التابعة لمركز بحوث الصحراء بالساحل الشمالي الغربي خلال المواسم الصيفية والشتوية اللاحقة لأعوام ٢٠٠٢، ٢٠٠٣ ، ٢٠٠٤ على الترتيب بهدف دراسة تأثير لون فيلم البولي إثيلين المستخدم (شفاف وأصفر) ، سمك الفيلم (١٥٠، ٣٠٠ ميكروميتر) وفترات التشميس (صفر، ٢٨ ، ٤٢ ، ٥٦ يوما) بدأ من ٢٧ يونيو على نمو وإنتاجية محصولي الفول البلدي والذرة الشامية اللاحق له وكذا درجة نمو الحشائش المصاحبة لهما. وقد أظهرت النتائج المتحصل عليها الأتي:

- أدي التشميس بإستخدام أفلام البولي إيثيلين الشفافة لحدوث زيادة فى درجة حرارة التربة عن تلك صفراء اللون وكذا درجة حرارة الهواء الجوي. كانت الزيادة أعلي عند عمق ٥ سم من سطح التربة مقارنة بعمق ١٠ سم.
- حدث نقص معنوي واضح في نمو الحشائش المصاحبة للفول البلدي والذرة متمثلا في الوزن الغض والجاف. كان ذلك صحيحا بإستخدام الفيلم الشفاف عن الأصفر بزيادة فترة التشميس من ٤-٨ أسابيع، وكذا بزيادة سمك الفيلم من ١٥٠ إلي ٣٠٠ ميلليميكرون.
- حدثت زيادة فى صفات نمو كل من محصول الفول البلدي والذرة الشامية اللاحق له وكذا المحصول ومكوناته بإستخدام الفيلم الشفاف وزيادة فترة التشميس حتى ٨ أسابيع وكذا سمك ٣٠٠ ميلليميكرون.