Revista Internacional de **BOTANICA** EXPERIMENTAL **ΦYTON** International Journal of EXPERIMENTAL **BOTANY**

Fundada en 1951 por Founded 1951 by
Miguel Raggio & Nora Moro-Raggio
Editor: Dr. Miguel Raggio
FUNDACION ROMULO RAGGIO
Gaspar Campos 861, 1638 Vicente López (BA), Argentina

53° ANIVERSARIO 2004: 205-211 53rd ANNIVERSARY

Solarization and goat manure on weeds management and melon yield

(with 1figure & 2 tables)

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Abstract. The effect of soil solarization during 30 days and the fertilize with goat manure to the soil at the rate of 0,20 and 40 t ha^{-1} was studied; the objective of this experiment was to increase soil temperature in order to study its effect on weeds population and on muskmelon yield. Solarization produced maximum soil temperatures of 55°C and 44°C at the depth of 1.5 and 10 cm respectively, which in turn clearly reduced the emergence and growth of weeds in solarized plots. Goat manure only increased soil temperature by 1.5 to 2.5°C, but it had an apparent antagonist effect on weeds density, however, this effect was not clear on solarized plots. Perennial weeds like *Cyperus esculentus* was affected but not eliminated by solarization. The effect of high soil temperatures on weed control was reflected in higher melon yield of solarized treatments, meanwhile, non-solarized plots yield was significantly reduced, reporting 11.83 t ha^{-1} compared to almost 30 t $h^{-1}$of solarized treatments. Yield of control plots was significantly increased by goat manure. We concluded that soil solarization combined with organic matter could be a sustainable alternative to methyl bromide fumigation or to the use of herbicides for weed control and for increasing melon yield.

Key words: weeds control, organic amendment, muskmelon, soil temperature.

Herbicides for weed control is an important practice in agroecosystems to protect crop production, however, these pesticides are expensive, are potentially detrimental to the environment, may affect some beneficial organisms indirectly, and decrease overall biodiversity, including pests and their natural enemies, by removing weeds that might

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This work was supported by CONACYT-SIREYES and Fundación Produce Coahuila, A. C.

Received 20.V.2003; accepted 26.VI.2003

act as hosts or shelter for many organisms (22). Crop losses in Mexico owing to inadequate weed control is difficult to asses due to lack of statistics, however, it had been estimated a crop yield reduction around 50% by weed competition (3).

In many parts of the world methyl bromide (MB) is used to reduce or eliminate population of weeds, soilborne bacteria, fungi and nematodes, however, it causes hazards to human and animal health as well to the environment. Only in the USA are being used around 21,000 tons of MB per year, but globally the figure raises to 72,000 ton. Most of all MB being used is dissipated to the atmosphere, depleting the atmospheric ozone. Because of this problem, the use of MB in different countries is scheduled to be phased out by 2005-2015, according to the revised Montreal Protocol (21). There is an urgent need for alternative solutions like soil solarization, alone or in combination with other methods, in the context of an integrated pest management approach (20, 13).

Soil solarization controls many annual and perennial weeds; winter annual weeds seems to be especially sensitive to this practice, and control of winter annuals is often evident for more than one year following solarization (6, 4). Addition of fertilizers and organic amendments, especially composts or chicken manure, can suppress soilborne plant pests (2, 8), therefore, the purpose of this study was to determine the effect of soil solarization amended with goat manure on weeds control and melon yield.

MATERIALS & METHODS

Location and characteristics of the study area. The experiment was undertaken in Saltillo, Coah., México during the 2001 growing season. The soil type is an alluvial clay loam, pH=8.1, EC=3.7 mS cm^{-1}, organic matter content 2.38%, having a maximum water holding capacity of 14.7% and bulk density 1.26g cm^3. Muskmelon cv. Early Deligth were sowed and cultivated using standard plasticulture practices. Beds were 20 cm high and 72 cm wide, containing 2 rows of plants spaced 30 cm apart within, and between rows with beds spaced 1.4 m on center. A randomized complete block design with four replications per treatment was used; each of three adjacent beds 4 m long x 4.2 m wide. Treatments studied were solarization (30 days and bare soil) and three goat manure doses (0, 20 and 40 t ha^{-1}) incorporated to the soil.

Solarization and goat manure treatments. Soil solarization treatments with 30 days duration was applied from mid June to mid July as described elsewhere (17, 12). Clear PE sheets, 50 µm thick UV-stabilized, were used to cover the soil, after it had been irrigated to field capacity. Each plastic sheet was centered on the area where the bed was subsequently made by hand to ensure that all the soil mounded in the bedding process had been solarized. After soil preparation and before the

clear plastic mulching, goat manure containing 2.77, 0.78 and 2.39% N, P, K respectively, was uniformly applied and hand incorporated in plots being solarized. After solarization, clear polyethylene was replaced with black plastic mulch (100 µm thick) when the plots were planted by hand with melon seeds cv. Early Deligth, on July 14 with a double plant rows. To study temperature regimes under the plastic mulch and on bare soil, daily temperatures were measured with a Fluke thermometer model 52 II and copper-constantan thermocouples model 80 Pk-1, which were placed at the 1.5 and 10 cm depths on beds center or areas being solarized. Air temperature was also monitored with a thermometer. Prior to solarization, a drip irrigation system was installed having a tape at the row center which was buried 2.5 cm below the soil surface to avoid being damaged.

Weeds sampling and fertigation. Weeds density, diversity and dominance was determined before and after solarization treatments, and at crop harvest. Sampling was performed by using a metallic quadrant (50x50 cm). The first sampling was done immediately after solarization and the second one during harvest time. Samples were taken at each treatment from the center of the plot. Water and fertilizers were applied every other day throughout the crop cycle with a fertigation equipment. Fertilization formula applied was 300-150-200-150 (N-P-K-Ca), having as the principal fertilizer sources: nitrates of ammonium, potassium and calcium, and phosphoric acid at 65%. Insect control was based on a continuous monitoring upon the insect arrival, as well as the first disease symptoms. One harvest was realized 86 days after the planting date, the second was done 10 days later.

RESULTS & DISCUSSION

Soil temperature. During the hottest day (July 11) at the 1.5 cm soil depth soil temperature (ST) reached a maximum value of 54.5°C, having a difference of 16.5°C compared to ST of control plots. Solarized plots amended with goat manure increased its ST by 1.5 to 2.5 °C over those without organic matter, similar results had been reported by other researchers (8), who had found an increase of ST in the range of 2 to 3°C in solarized soils amended with chicken manure, compared to solarized plots without organic matter. Soil thermal accumulation in solarized and control treatments registered as number of hours in the range of 35 to 50°C throughout the solarization period is presented in Fig 1. This temperature range is considered the treshold in which most weeds and a great variety of plant pathogens are killed by solarization (5). Our information reveal that at the depth of 1.5 cm where most of the seed bank is found, thermal accumulation was 132.1 h, meanwhile in control plots accumulation was only 7.3 h; possibly the higher temperature reached in solarized plots was the most important factor causing weeds death.

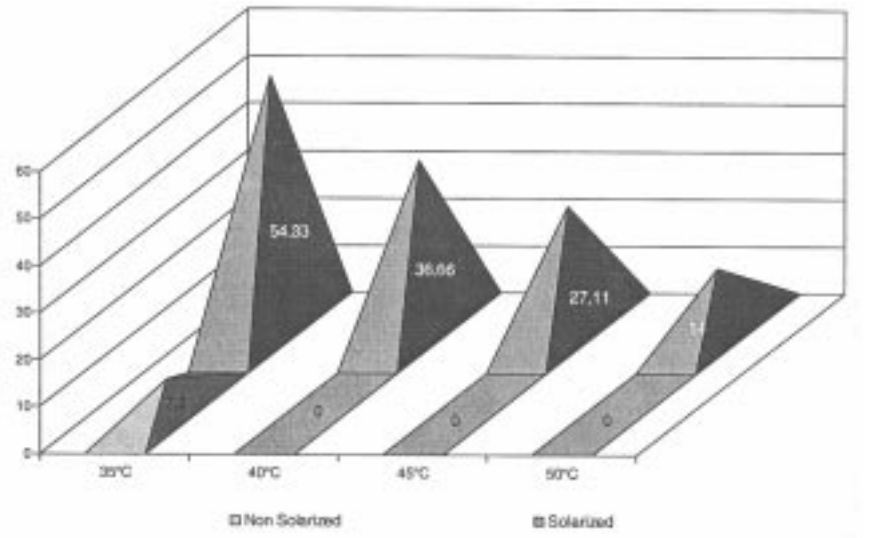

Fig.1.– Thermal accumulation (hr) at the 1.5 cm soil depth throughout the days of highest temperature on solarized and control plots.

Weeds population and density. Diversity of weeds and its population density was clearly affected by solarization, because we did not find any weed survival after solarization treatment, meanwhile, in control plots there were found numerous weeds belonging to different species. Plant species with higher population density and dominance were: *Cyperus esculentus*, *Portulaca oleracea*, *Setaria geniculata* and *Amarantus hibridus* with 28.5, 10.25, 9.25 and 7.75 plants m^{-2} respectively (Table 1). *C. esculentus* even though was eliminated with solarization, recovered during the weeks following removal of the plastic mulch, reaching levels near those found in control plots. Partial elimination of this perennial weed had been also observed in different regions of the world by other authors (16, 1, 10). It also had been reported that a marginal o inefficient solarization not only fail to control weeds belonging to *Cyperus* genus, but improves it growth (6). Solarization data related to tomato and pepper crops (19), also indicate that *C. esculentus* was poorly controlled, even though soil was fumigated with MB. Table 1 also indicates that goat manure doses had a clear effect on weeds density in non-solarized plots, since with 0, 20 and 40 kg ha^{-1}, we found an average of 58.25, 32.0, y 22.0 plants m^{-2} respectively, this suggests that goat manure had an inhibitory effect on weeds population. These results possibly are due to soil heating and that the organic matter incorporated, provoked a chain reaction of chemical and microbial degradation, this in turn generated toxic liquid and volatile compounds, that accumulated below the plastic mulching, increasing toxicity against the soil flora and fauna (7).

Table 1.– Weeds density (m^{-2}) found in solarized and control plots with or without doses of goat manure.

Species	Non-solarized Goat manure (t ha^{-1})			Solarized Goat manure (t ha^{-1})		
	0	20	40	0	20	40
Amaranthus blitoides	0.5cd*	1.25c	0.25c	0	0	0
Amaranthus hibridus	7.5b	7.75a	1.75b	0	0	0
Auria coccinia	0d	0d	2.0b	0	0	0
Cynodon dactylon	2.5c	0d	1.0bc	0	0	0
Cyperus esculentum	28.5a	7.25a	0c	0	0	0
Chenopodium murale	1.0cd	0.75c	0.25c	0	0	0
Echinocloa crusgalli	0d	0.75c	0.25c	0	0	0
Malva parviflora	0d	0.25cd	0c	0	0	0
Portulaca oleracea	7.5b	4.75b	10.25a	0	0	0
Salsola iberica	0d	0d	0.25c	0	0	0
Sanchus oleraceus	0d	0d	0.25c	0	0	0
Setaria adherens	0d	0d	2.0b	0	0	0
Setaria geniculata	9.25b	8.5a	3.0b	0	0	0
Sysimbrium irio	1.5cd	0.75c	0.75bc	0	0	0
Total	58.25	32.0	22.0	0	0	0

Means having the same letter within each column are not significantly different (P>0.05)

Table 2.– Mean comparison of melon yield in solarized and non-solarized plots with or without goat manure soil incorporated.

Treatment	Goat manure (t ha^{-1}) 0	20	40	Mean
Non-solarized	11.63	18.99	25.68	18.79[a]
Solarized	29.50	29.82	28.85	29.39[b]
Mean	20.57	24.41	27.27	24.09

Crop production. Melon yield was significantly increased due to solarization, having statistical differences among solarized plots and the control (Table 2). Average yield of non-solarized treatments was 18.79 t ha^{-1}, meanwhile, solarized plots reported 29.39 t ha^{-1} (a 64% increase). This difference was attributed in part to weeds competition for water, light and nutriments in the non-solarized plots. Other authors (14), also had reported noticeable melon yield increase whit solarization. This technique also promoted yield increase of several crops like watermelon (12), beet (18), tomato (13), carrot, cabbage and faba bean (15). Goat manure had a remarkable effect on yield, specially on non-solarized treatments, where it was detected a direct positive relationship between yield and

organic matter incorporated, because with 20 and 40 t ha^{-1}, melon yield was increased by 63.29 and 120.81 % respectively. Yield increase of cabbage crop due to chicken manure amendment in solarized soils had been reported (9), other researchers also found that solarization amended with chicken manure increased yield of *Coriandum sativum* (10). From this study we concluded that solarization clearly reduced the emergence and growth of weeds; goat manure increased soil temperature by only 1.5 to 2.5°C, but it had an apparent antagonist effect on weeds density, however, this effect was not clear on solarized plots. Perennial weeds like *Cyperus esculentus* was affected but not eliminated by solarization. Melon yield was significantly increased by solarization and by goat manure; therefore, soil solarization combined with organic matter could be a sustainable alternative to MB fumigation or to the use of herbicides for weed control and for increasing melon yield.

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