Journal of Applied Biosciences 42: 2867 – 2875

ISSN 1997–5902

Weed control and yield improvement of *Solanum tuberosum* (L.) in Adamawa region (Cameroon) by soil solarization and chicken manure.

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Original Submitted In 23rd February 2011. Published online at www.biosciences.elewa.org on June 14, 2011.

ABSTRACT.
Objective: In Adamawa region (Cameroon), the reduction of crop productivity due to inappropriate weed management can be estimated to 90%. The use of herbicides is a principal main method of weed control but is expensive for resource poor farmers and detrimental to the environment. A sustainable solution for weed control is an urgent challenge.
Methodology and results: A randomised complete block design with 3 replications was used. Treatments were a one month soil solarization alone (SS), chicken manure (8.75 $t.ha^{-1}$) alone (CM), soil solarization + chicken manure (SCM), and untreated control (C). Solarization and chicken manure increased soil temperature and reduced the emergence and growth of weeds. Solarization technique reacts like herbicide on recalcitrant weeds like *Imperata Cylindrica,* the most troublesome weed of vegetable crops in sub-Saharan Africa. Chicken manure enhances the weed control effect of solarization technique. Immediate effect of this weed control is potatoes yield improvement. SCM treatment increases potatoes yield by 91 %.
Conclusions and application of findings:
Making use of the weed control by the soil solarization technique, farmer can save money and time of weeding. High temperature reached under the plastic mulch removes seed-coats dormancy of some leguminous genus that emerges as weeds. These atmospheric nitrogen fixing species reinforce the positive effect of solarization technique by having positive impact on soil fertility. Chicken manure has also an apparent antagonist effect on weeds density. Potatoes yield was significantly increased by solarization and by chicken manure; therefore, soil solarization combined with organic mater such as chicken manure could be a sustainable alternative strategy to the use of herbicides for weed control and for potatoes yield improvement in the context of Adamawa region (Cameroon). This sustainable practice is cheaper for limited-resource farmers, is harmless to human and is environment-friendly. It may be mostly useful in agroecosystems that do not use herbicide, such as in biological agriculture practised by organic growers.
Keywords: Soil solarization, chicken manure, *Solanum tuberosum* L.*, weeds* control, yield.

INTRODUCTION

Weeds reduce the quality and quantity of agricultural production, and secondly they produce allergens or contact dermatitis that affects the publics health (Ware and Whitacre, 2004; Kostov and Pacanoski, 2007). Weeds are different from the other pests that pose problems in crop production because the presence of weeds is relatively constant, while outbreaks of insects and disease pathogens are sporadic (Gianessi and Sankula, 2003). Approximately 10% of all plant species are weeds, for a total of some 30,000 weed species. Of these, 1,800 cause serious economic losses in crop production, and about 300 species plague cultivated crops throughout the world. The United States has become home to 70% of the world's worst weeds (Ware and Whitacre, 2004). In North America, weeds reduce the value of rangeland by US$1 billion per year or 10% of total value (Pimentel *et al*., 2000). Crop losses in Cameroon due to inadequate weed control are not clearly assessed because of the lack of statistics; but depending on the crop, it can be estimated from 15 % (wheat) to 70 % loss or more (corn). In Adamawa region (Cameroon), the reduction of crop productivity due to inappropriate weed management can be estimated to 90% in some cases.

Herbicides, or chemical weed killers, largely replace mechanical methods of weed control in countries where intensive and highly mechanized agriculture is practiced. They provide a more effective and economical means of weed control than cultivation, hoeing, and hand pulling. In many parts of the world, herbicides are used to reduce or eliminate population of weeds, soil borne bacteria, fungi and nematodes (Knezevic *et al.,* 2003). The widespread use of herbicides in crops grown throughout the United States has resulted in yield increases, savings for growers and reduction of soil erosion (Ware and Whitacre, 2004). In these countries, around 21,000 tons of Methyl Bromide were used per year, but globally the figure rises to 72,000 tons per year (Lira-Saldivar *et al*., 2004). However, these herbicides not only are expensive for smallholder farmers in underdeveloped countries, but also are potentially detrimental to the environment and are also hazardous to human and animal health. They may indirectly affect some beneficial organisms and decrease overall biodiversity (Yardim and Edwards, 2002). Most of all Methyl Bromide used is dissipated to the atmosphere, depleting the atmospheric ozone (Lira-Saldivar *et al*., 2004).

An integrated approach to weed management that uses all available weed control strategies to manage weed populations can reduces the use of herbicides and optimizes economic returns. In this context, there is an urgent need for alternative solutions for weed control, like soil solarization, alone or in combination with other methods (Ioannou, 2000; Singh, 2006; Cohen *et al*., 2008).

Solarization is a simple non chemical technique that captures the radiant heat and energy from the sun and causes physical, chemical, and biological changes in the soil. It consists of covering the soil with a clear plastic sheet for 4 to 6 weeks during a hottest period of the year, when the soil will receive maximum direct sunlight. When properly done, the top 15 cm soil will heat up to as high as 52 °C (Singh, 2006).

Soil solarization controls many annual and perennial weeds (Marenco and Lustosa, 2000). Winter annual weeds seem to be especially sensitive to this practice, and their control is often evident for more than one year following solarization (Peachey *et al.,* 2001; Boz, 2004). Addition of fertilizers and organic amendments, especially composts or chicken manure, can suppress soil borne plant pest (Benlioglu *et al.* 2005).

The present experiment was conducted to test the effect of soil solarization, chicken manure, and soil solarization combined with chicken manure on weeds and potatoes yield in Adamawa region (Cameroon).

MATERIAL AND METHODS

Location and characteristics of study site: Experiments were carried out in the town of Dang, (Ngaoundere in Adamawa region), located in the Guinea savannah zone of Cameroon (7°24.61'N and 13°34.24'E, at 1155,8 m elevation). The soil for the experimental site was brown reddish, developed on a basaltic rock and its analysis done at the beginning of the study indicated a low natural fertility, with pH of 4.8, 0.13 gN.100g^{-1} soil DW, 0.4 gP.100g^{-1} soil DW, and 2.9 g of total C.100g^{-1}soil DW. The relative humidity was 80%.

Experimental design: Experiments consisted of 4 treatments including one month soil solarization alone (SS), chicken manure (8.75 t.ha^{-1}) alone (CM), soil solarization combined with chicken manure (SCM), and untreated control (C). The "Diamant" potatoes cultivar was used. Experimental plots consisted of 2 rows arranged in a randomised complete block design, with 3 replications at 3 different blocks per treatment and the size of each plot was 4m x 4 m. Prior to treatments, the soil was hand –tilled using hoe and beds were raised at 25 cm in height and 60 cm in width. Beds were spaced at 50 cm each other. To increase the efficiency of the process, soil was maintained smooth on the surface and wetted to a depth of 15 cm to 20 cm prior to solarization or chicken manure application.

Solarization technique and chicken manure application: Solarization technique with 30 days duration was applied during the hottest period of the year (from mid March to mid April). Solarization technique was conducted in the field by covering hand tilled 0.6 x 4 m beds with a 0.8 x 4.5 m transparent polyethylene sheets (50 µm thickness). Each plastic sheet was centred to ensure that all the soil mounded in the bedding process had been solarized (Megueni *et al*., 2006; Ngakou *et al*, 2006). The edges of the plastic sheet were covered with soil to avoid wind disturbance. Chicken manure containing 14 gN.100g^{-1} soil DW, 11 gP.100g^{-1} soil DW and 5 gK.100g^{-1} soil DW constituted organic amendment (treatment CM). After soil preparation, this organic amendment was uniformly applied and hand incorporated on the soil surface of some plots at the rate of 8.75 t.ha^{-1}. Soil solarization combined with chicken manure (SCM) was used as separate treatment in the experiments. Combination treatment involving CM and solarization technique was applied as described above. Then, raised beds were prepared and the soil surface was manually covered with a clear polyethylene sheet for one month duration after incorporation of chicken manure. All these three treatments (SS, CM, SCM), were compared to the untreated control treatment (C), which was plot that receive potatoes seeds without prior solarization or chicken manure application.

Soil temperature assessment: During solarization, soil temperature was recorded continuously once a day (at mid-day) during one month, at 5 and 25 cm depths, using a thermo hygrometer buried in the centre of each plot.

Seeding: After solarization, the polyethylene sheet was removed. Plots were left uncovered during the following 24 hours before sowing to allow total refreshment of the soil. After that, each plot (treated and untreated control) received 38 seeds of potatoes cv Diamant at 10 cm depth, representing a rate of 27,143 seeds.ha^{-1}.

Weeds sampling: Weeds density, diversity and dominance were determined before and after weeding. Weed samples were taken for each treatment from the centre of the bed using 1 x 1 cm quadrates. Four quadrates were used per bed. The collected plant material was pressed, dried and kept at room temperature for further identification using appropriate literature or taxonomy keys.

Yield evaluation: Potatoes yields were evaluated after manual harvesting at the maturity of tubers (at 90 days after planting). So, 20 plants of each treatment were randomly harvested and tubers were weighed. The yield was expressed in term of t.ha^{-1}.

Statistical analysis: Data were statistically analyzed by ANOVA using a Statgraphic plus computer program. Means were separated, if possible, by least significant difference (LSD), but only when the ANOVA F-test was significant at $P \leq 0.05$ level.

RESULTS

Effect of solarization technique on soil temperature: Means temperatures present a statistically significant difference between the treatments ($P \leq 0.05$). After 15 days under covering, all treatments present a highest temperature (figures 1 and 2). In both depths, soil temperature was approximately higher in solarized plots compared to unsolarized one. At 5 cm depth, the maximum soil temperature average was 52.23 °C in the solarized plot vs 30.84 °C in unsolarized plot (Figure 1). Chicken manure raised the soil temperature by 23.19°C in solarized plot and by 4.96°C in unsolarized plot. Soil temperature decreased when going in depth (figures 2). So, at 25 cm depth, the maximum soil temperature average was 33.97 °C in solarized plot vs 28.20°C in unsolarized one, creating a low difference of 5.77°C comparatively to the difference of 23.19°C obtained at 5 cm depth.

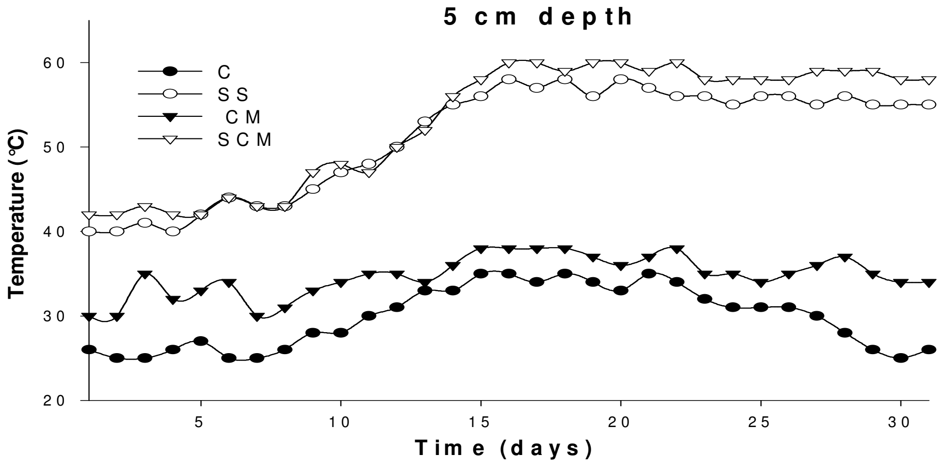

Figure 1: Daily temperature (°C) at 5 cm depth according to different treatments

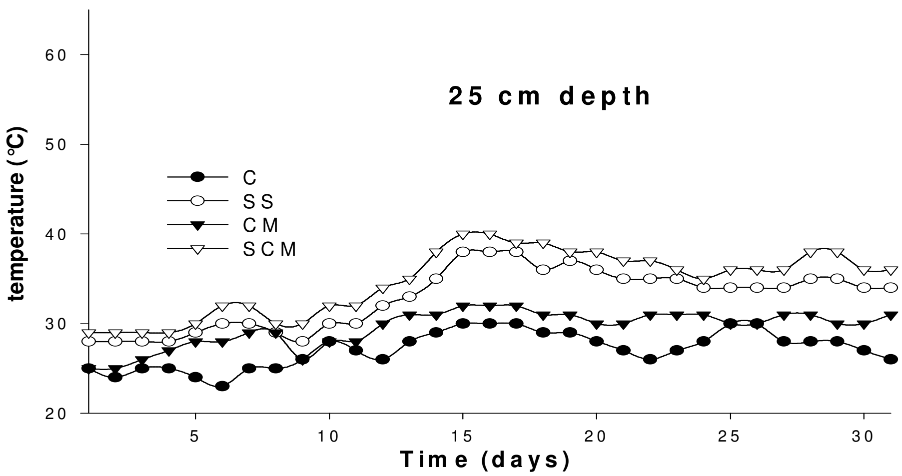

Figure 2: Daily temperature (°C) at 25 cm depth according to different treatment
C: untreated control; CM: Chicken manure amendment; SS: Soil solarization; SCM: Soil solarization + Chicken manure amendment.

Furthermore, soil temperature was slightly high in the presence of chicken manure; so, in CM treatment, a maximum soil temperature is 30.58°C and in SCM treatment, the value rises at 35.78 °C, creating with the untreated control a difference of 5.77 °C and 7.58 °C respectively. Weeds population and density as affected by soil solarization and chicken manure: Weeds diversity and density was clearly affected by solarization, because weeds survival had a 91.06 % reduction after solarization treatment; on the other hand, numerous weeds belonging to different species were found in control plots (Table 1). Weed control effects of solarization was enhanced when this treatment was combined with chicken manure (95.48 % reduction). Plant species with higher population density and dominance were: *Imperata cylindrica* (L.) P. Beauv. Var Africa (cogon grass), *Spermacoce spp* (Bristly button weed*), Pennisetum polystachion* (L.) Schull. (Mission grass)*, Pennisetum pedicellatum* (L.) Schull (Hairy fountain grass)*, Hyparrhenia bracteata* (Humb. Et Bompl. Ex Willd) Stapf (Thatching grass)*, Fimbristylis sp (Rusty sedge),* with 69.23, 43.09, 17.54, 13.00, 12.26, 9.62 weeds.m^{-2} respectively (Table 1). Although *I. cylindrica* population was reduced by solarization (33.35 %), it reached levels closed to those found in control plots after removal of the plastic mulch. Maximum reduction of this weed was also noticed when solarization was combined with chicken manure (66.67

%). Chicken manure reduced the appearance of *I. cylindrica* by 16.03 %. Table 1 also indicates that chicken manure had a clear effect on weeds density in unsolarized plots.

Table 1: Weeds density (number.m^{-2}) before weeding as affected by soil solarization and chicken manure

Species	Family	Control	CM	SS	SCM
Imperata cylindrica (L.) P. Beauv var. Africa,	Poaceae	69.23±1.10	58.13±1.00	46.14±0.40	23.07±0.31
Spermacoce spp	Rubiaceae	43.09±0.12	32.03±0.22	20.55±0.50	5.23±0.01
Pennisetum polystachion *(L.). Schull*	Poaceae	17.54±0.05	09.04±0.20	11.66±0.22	6.00±0.21
Pennisetum pedicellatum (L.). Schull	Poaceae	13.00±1.03	07.00±1.20	1.00±0.21	5.00±0.012
Hyparrhenia bracteata (Humb. Et Bompl. Ex Willd) Stapf	Poaceae	12.26±1.02	06.16±0.12	4.00±0.04	0.12±0.01
Fimbristylis sp	Cyperaceae	9.62±0.11	04.33±0.21	1.11±0.30	0
Corchorus sp	Tiliaceae	1.12±0.22	0.60±0.12	0.22±0.11	0
Ageratum Conyzoides (L.)	Composeae	0.94±0.13	0.55±0.21	0.11±0.05	0
Crotalaria retusa (L.)	Papilionaceae	7.35±0.31	0.44±0.02	2.00±0.01	9.0±1.40
Senna tora (L.)	Papilionaceae	1.30±1.51	1.2±0.30	9.33±0.04	2.8±0.05
Corchorus olitorius (L.)	Tiliaceae	1.00±0.10	0.80±0.04	0	0
Aspilia sp	Asteraceae	0.78±0.50	0.45±0.03	0	0
Laggera ptedunta	Lamiaceae	0.84±0.04	0.24±0.04	0	0
Oldenlandia corymbosa	Rubiaceae	2.01±0.02	1.30±0.10	0	0
Indigofera dendroïdes Jacq.	Papilionaceae	0	0	3.02±0.02	0
Leucas martinicensis (Jacq) R. Br.	Lamiaceae	1.00±0.01	0	0	0
Tephrosia sterophylla	Papilionaceae	0	0	2.12±0.01	0
Total		1133.46	122.27	101.26	51.22
Effect (%)*	89.21	91.06	95.54		

CM: Chicken manure ; SS: Soil Solarization ; SCM: Solarization + Chicken manure. Effect (%)* represents the ration (Control - treated) / control x 100.

Table 2 : Weeds density (number.m^{-2}) after weeding as affected by soil solarization and chicken manure

Species	Family	Control	CM	SS	SCM
Imperata cylindrica (L.) P. Beauv var. Africa,	Poaceae	58.31±0.11	48.03±0.05	33.09±0.20	13.03±0.40
Spermacoce spp	Rubiaceae	34.01±1.20	22.00±0.11	10.45±0.40	0.45±0.02
Pennisetum polystachion *(L.). Schull*	Poaceae	7.45±0.01	04.02±0.01	01.56±0.12	0.46±0.12
Pennisetum pedicellatum (L.). Schull	Poaceae	3.00±0.03	03.00±0.12	0	0
Hyparrhenia bracteata (Humb. Et Bompl. Ex Willd) Stapf	Poaceae	2.16±0.20	0	2.02±0.02	0
Fimbristylis sp	Cyperaceae	0.52±1.10	0	0	0
Corchorus sp	Tiliaceae	0.22±0.11	0	0	0
Ageratum Conyzoides (L.)	Composeae	0.10±0.31	0	1.00±0.10	05.00±1.20
Crotalaria retusa (L.)	Papilionaceae	0.37±0.13	0	4.23±0.02	0.80±0.01
Senna tora (L.)	Papilionaceae	0	0	0	0
Corchorus olitorius (L.)	Tiliaceae	0	0	0	0
Aspilia sp	Asteraceae	0	0	0	0
Laggera perduta	Lamiaceae	1.02±0.01	0	0	0
Oldenlandia corymbosa	Rubiaceae	0	0	0	0
Leucas martinicensis (Jacq) R. Br.	Lamiaceae	0	0	0	0
Total		106.14	77.05	52.26	19.74
Effect of weeding*	90.63	27.40	50.76	81.40	

Effect of weeding: represent [the ration of (results after weeding (see table 1) – result before weeding)/ results after weeding]x100

CM: Chicken manure; SS: Soil Solarization; SCM: Solarization + Chicken manure

Since with 8.75 Kg ha^{-1} an average of 122.27 $weeds.m^{-2}$ (89.21 % reduction) was found, this suggested that chicken manure had an inhibitory effect on weeds population. Solarization treatment alone or combined with chicken manure considerably reduced the density of some weeds species and lead to the disappearance of some species (Table 1). Some genus of Legumes like *Crotalaria (Wedge-leaf rattlepod), Senna (Locust plant), Indigofera (Silky indigo)* and *Tephrosia (Wild indigo)* which were almost absent in control plots appeared after solarization with 91.06 and 95.48 % of weeds reduction respectively, solarized plots alone or combined with chicken manure did not need weeding. After weeding, the density of weeds was considerably reduced in all plots (Table 2). The reduction of *I. cylindrica* density varied from 15.87 % (control) to 48.82 % (solarized plots combined with chicken manure). Decrease of the density of others species was also important. It was noticed that with the solarization technique, the number of weedings was reduced even if plots were colonised by recalcitrant weeds like *I. cylindrica* (Table 2).

Weeds sampling was performed as in table 1. Solarization technique, alone or combined with chicken manure, reduced the set-up of weeds. so Single soil solarization reduced weeds emergency but didn't have important effect of potatoes yield. The most noxious weed (*Imperata cylindrica*) is partially eliminated by solarization technique. With this technique, some weeds completely disappeared in the farm (*Corchorus olitorius* (Nalta jute)*, Laggera perduta* (Silky sage), *Oldenlandia corymbosa* (Flat top file)); weed control effects of solarization technique was enhanced by chicken manure. Some legumes genera absent before solarization appeared because of the break-down of seed dormancy by the heat.

Effect of treatments on potatoes yield: Compared to untreated control, all treatments significantly increased potatoes yield ($P < 0.05$) (Table 3). Average yield of unsolarized treatments was 4.97 $t.ha^{-1}$, and 5.68 $t.ha^{-1}$ for solarized plots, representing a 14.28 % increase. Chicken manure had a remarkable effect on yield, especially on solarized plots, where a direct positive relationship between yield and organic matter incorporated was detected (yield increased of 55.13 %) ($P < 0,05$).

Table 3: Effect of different treatments on potatoes yield (t/ha)

	Yield (t/ha)	Effect of chicken manure (%)*	Effect of solarization (%)**
Control	4.97^{a}		
CM	6.28^{bc}	26.35	
SS	5.68^{ab}		14.28
SCM	7.71^{d}	55.13	22.77

CM: Chicken manure; SS: Soil Solarization; SCM: Solarization + Chicken manure
Values within a column with the same letter are not significantly different at 5 % level.
* = ((amended treatment – control)/control) x 100
** = ((solarized treatment – control)/control) x 100

DISCUSSION

The increase of soil temperature by soil solarization technique was probably due to the heat required by water to evaporate, which was subsequently transferred to the polyethylene sheet as indicated by the condensation of water on the lower surface of sheet. Soil temperature range of 40 to 58 °C was considered as the threshold in which most weeds and great varieties of plant pathogens were killed by solarization (Pinkerton *et al*., 2000); this would constitute an advantage for the plant growth.

Solarization technique reacted like herbicide on recalcitrant weed like *I. Cylindrica.* This constitutes an enormous benefit for farmer who can save money and time for the weeding. Partial elimination of *Cyperus rotundus (Common hut sedge),* a perennial resistant weed had also been observed in different regions of the world by other authors (Stapleton *et al*., 2005; Webster, 2005). Also, evaluating control options for *Cyperus rotundus* and *Cyperus esculentus (Umbrella sedge)* within cropping systems in southern California, Wang *et al*. (2008) found that broccoli yield was reduced by 44 % compared with weed-free control, while the solarization treatment increased broccoli yield by 64 %, compared with the non-solarized treatment. It had been also reported that a marginal or inefficient solarization not only fails to control *C. rotundus*, but improves its growth (Webster, 2005). It has been reported that germination of some seeds may be enhanced when soil temperatures reach 50 to 60°C, which break the seeds dormancy (Cohen et al. 2008). The growth of Legumes belonging to *Crotalaria, Senna, Indigofera* and *Tephrosia* genus after solarization can be explained by the high temperature reached under plastic sheets which break or removed seed coats dormancy of these species. Similar results were reported by Marenco and Lustosa (2000) on *Indigofera hirsuta* seeds. It was noticed that these genus which appear after soil solarization were atmospheric nitrogen fixing plants ; thus, they reinforce the positive effect of solarisation technique by having positive impact on soil fertility.

Solarized plots amended with chicken manure increased soil temperature by 1 to 2,5 °C over plots with no organic mater, similarly to results reported by other researchers (Pinkerton *et al.* 2000), who also found an increase of soil temperature in the range of 2 to 3 °C in solarized soils amended with chicken manure. Weed control effects of Solarization technique was enhanced by the application of chicken manure. The inhibitory effect of chicken manure on weeds population was probably due to heating or to the fact that the organic matter incorporated may have provoked a chain reaction of chemical and microbial degradation, which in turn have generated toxic liquid and volatile compounds that accumulated below the plastic mulching, increasing toxicity against the soil flora and fauna (Gamliel *et al.,* 2000). Solarization combined with chicken manure could be an integrated approach for weed control because it is cheaper for limited-resource farmers, harmless for human, and environment-friendly. This technique may be mostly useful in agroecosystems that do not use herbicide, such as in biological agriculture practised by organic growers. Soil solarization can also be a safe and effective method for controlling soil pests (Stapleton *et al*., 2005, Sahile *et al*., 2005).

The increase of potatoes yield due to solarization can be attributed in part to the elimination of competition between crop and weeds for water, light, nutrients and space of development. Others authors (Gamliel *et al.,* 2000; Ngakou *et al*, 2006) also reported noticeable potatoes yield increase with solarization. This technique also promoted yield of several crops like watermelon (Ioannou *et al*., 2000), beet (Ricci *et al.,* 2000), tomato (Ioannou, 2000; Sahile *et al*., 2005); carrot (Marenco and Lustosa, 2000), cabbage and faba bean (Mauromicale *et al.,* 2001), soybean (Megueni *et al.,* 2006), tomato (Kaskavalci, 2007), table beet (Gasoni *et al*., 2008) The direct consequence of CM treatment on the weeds reduction was the enhancement of potatoes yield. Yield increase of cabbage crop (Haidar and Sidahmed, 2000), *Coriandum sativum* (Stapleton *et a*l., 2005), tomato (Kaskavalci, 2007) due to chicken manure amendment in solarized soils had also been reported.

From this study it was concluded that solarization clearly reduced the emergence and growth of weeds. Chicken manure increased soil temperature by only 1.5 to 2.5°C, and it had an apparent antagonist effect on weeds density. Perennial weeds like *Imperata cylindrica* was affected but not eliminated by solarization. Potatoes yield was significantly increased by solarization and by chicken manure; therefore, soil solarization combined with organic mater such as chicken manure could be a sustainable alternative strategy to the use of herbicides for weed control and for potatoes yield improvement in the context of Adamawa region (Cameroon).

In future prospects, more studies to test solarization technique with many other crops and in other agroecologycal zones, to assess its effects on soil micro organisms should be done.

ACKNOWLEDGEMENTS

This study would have not been possible without the effective collaboration of the laboratories of ENSAI (University of Ngaoundere) and IRAD-Wakwa, where practical aspects of the work were carried out. The authors wish to thank the University of Ngaoundéré for the research plot.

REFERENCES

Benlioglu S, Boz Ö, Yildiz A,, Kaskavalci G,, Benlioglu K, 2005. Alternative Soil Solarization Treatments for the Control of Soil-borne Diseases and Weeds of Strawberry in the Western Anatolia of Turkey. Journal of Phytopathology 153 (7-8): 423-430.

Boz Ö 2004. Efficacy and Profitability of Solarization for Weed Control in Strawberry. *Asian Journal of Plant Sciences* 3 (6): 731-735.

Cohen O, Riov J, Katan J, Gamliel A, Bar P, 2008. Reducing persistent seed banks of invasive plants by soil Solarization – The case of *Acacia saligna*. *Weed Science* 56 (6): 860-865.

Gamliel AM, Austerwiel J, Kritzman G, 2000. Non-chemical approach to soil borne pest management-organic amendments. Crop Prot 19: 847 – 853.

Gasoni L, Kahn N, Yossen V, Cozzi J, Kobayashi K, Babbit S, Barrera V, Zumelzú G, 2008. Effect of soil solarization and biocontrol agents on plant stand and yield on table beet in Córdoba (Argentina). Crop Protection 27 (3-5): 337- 342.

Gianessi L. and Sankula S. 2003. The value of herbicides in U.S. crop production. National Centre for food and Agricultural Policy. April 2003 Report.

Haidar MA and Sidahmed MM, 2000. Soil solarization and chicken manure for the control of *Orobanche crenata* and other weeds in Lebanon. Crop Prot 19: 169 -173.

Ioannou N, 2000. Soil solarization as a substitute for methyl bromide fumigation in green-house tomato production in Cyperus. Phytoparasitica 28 : 248 – 256.

Ioannou N, Poullis CA, Heale JB, 2000. Fusarium Wilt of watermelon in Cyprus and its management with soil solarization combined with fumigation or ammonium fertilizers. OEPP/EPPO Bulletin 30: 223 -230.

Kaskavalci G, 2007. Effects of soil solarization and organic amendment treatments for controlling *Meloidogyne incognita* in tomato cultivars in western Anatolia. Turk. J. Agric.For. 31: 159-167.

Knezevic SZ, Evans SP, Mainz M, 2003. Yield penalty due to delayed weed control in corn and soybean. Plant Management Network, 9 p.

Kostov T. and Pacanoski Z., 2007. Weeds with major economic impact on agriculture in Republic of Macedonia. Pak. J. Weed Sci. Res. 13 (3-4): 227-239.

Lira-Saldivar RH, Salas MA, Cruz J, Coronada A, Hernández FD, Guerrero E, Gallegos G, 2004. Solarization and goat manure on weeds management and melon yield. ΦYTON (International Journal of Experimental Botany) 73: 205-211.

Marenco RA, Lustosa DC 2000. Soil solarization for weed control in carrot. Pesq. Agropec. Bras., 35 (10): 2025 – 2032.

Mauromicale G, Resticcia G, Marchese M, 2001. Soil solarization, a non-chemical technique for controlling *Orobanche crenata* and improving yield of faba bean. Agronomie 21 : 757 – 765.

Megueni C, Ngakou A, Makalao MM, Kameni TD, 2006. Responses of soybean (Glycine max L.) to soil solarization and rhizobial field inoculation at Dang Ngaoundere, Cameroon inoculation at Dang Ngaoundere, Cameroon. Asian Journal of Plant Science 5 (5): 832-837

Ngakou A, Megueni C, Nwaga D, Mabong MR., Djamba FE, Gandebe M, 2006. *Solanum tuberosum* (L.) responses to soil solarization and arbuscular mycorrhizal fungi inoculation under field conditions: growth, yield, health status of plants and tubers. Middle-East Journal of scientific Research 1 (1): 23-30.

Peachey RE., Pinkerton JN., Ivors KL., Miller ML, Moore LW, 2001. Effect of Soil Solarization, Cover Crops, and Metham on Field Emergence and Survival of Buried Annual Bluegrass (*Poa annua*) Seeds. Weed Technology 15(1):81-88. 2001.

Pimentel D, Lach L., Zuniga R, Morrison D, 2000. Environmental and economic costs associated with non-indigenous species in the United States. Bioscience 50: 53-65.

Pinkerton JN, Ivors KL, Miller ML, Moore LW, 2000. Effect of Soil Solarization and Cover Crops on Populations of Selected Soilborne Plant Pathogens in Western Oregon. Plant Disease 84 (9): 952-960.

Ricci MS, De Almeida DL, Ribeiro RD, Aquino AM, Pereira JC, Polli D, Reis VM, Eklund CR, 2000. *Cyperus rotundus* control by solarization. Biol Agr Hort 17: 151 – 154.

Sahile G, Abebe G, Al-Tawaha A-RM, 2005. Effect of soil solarization on Orobanche soil seed bank and Tomato yield in Central Rift Valet of Ethiopia. World Journal of Agricultural Sciences 1 (2): 143-147.

Singh R, 2006. Use of soil solarization in weed management on Soya bean under Indian conditions. Tropical Science 46: 70–73.

Stapleton JJ, Molinar RH, Patterson KL, McFeeters SK, Shrestha A, 2005. Soil solarization provides weed control for limited-resources and organic growers in warmer climates. California Agriculture 59 (2): 84-89.

Wang G, McGiffen ME, Ogbuchiekwe EJ, 2008. Crop rotation effects on *Cyperus rotundus* and *C. esculentus* population dynamics in southern California vegetable production. Weed Research 48 (5): 420-428.

Ware GW, and Whitacre DM, 2004. An introduction to herbicides (2nd edition) Extracted from the pesticide Book, 6th edition) http://ipmworld.umn.edu/chapters/whitacreherb.htm

Webster TM, 2005 Patch expansion of purple nutsedge (*Cyperus rotundus)* and yellow nutsedge (*Cyperus esculentus*) with and without polyethylene mulch. Weed Science 53: 835-845.

Yardim EN and Edwards CA (2002). Effects of weed control practices on surface-dwelling arthropod predators in tomato agroecosystems. Phytoparasitica 30 (2): 379 – 386.