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Effect of Soil Solarization and Organic Fertilization on Yield of Maize (*Zea mays* L.) Genotypes and Soil Chemical Properties

A. Saloum and H. Almahasneh
Faculty of Agriculture, Damascus University, Syrian Arab Republic

Corresponding Author: A. Saloum, Faculty of Agriculture, Damascus University, Syrian Arab Republic

ABSTRACT

A field experiment was conducted in Abu-Jarash farm at the Faculty of Agriculture, Damascus University during March of the growing season 2013, to evaluate the effect of soil solarization and organic fertilization on the yield of some maize genotypes (Basel 1, Basel 2, Ghouta 1, Ghouta 82 and Local white) and soil chemical properties. The experiment was laid out according to Split-Split Plot Design (SSPD) with three replication for the studied genotypes and treatments. The statistical analysis results of the experiment clearly indicated to the existence of genetic variability in the response of studied maize genotypes to soil solarization and organic fertilization treatments. The genotype Ghouta-82 recorded significantly the highest mean values of grain yield and stover yield (7.99 and 9.83 t ha^{-1}, respectively) and was closely followed by the genotype Basel-2 (7.12 and 9.07 t ha^{-1}, respectively). Soil solarization and organic fertilization treatments recorded the highest mean values of grain yield and stover yield as compared to non solarization and no addition of organic manure treatments. In addition to that soil solarization and organic fertilization treatments recorded the highest mean values of organic matter and total nitrogen content in the soil as compared to non solarization and no addition of organic manure treatments. Therefore, it can be recommended to grow the genotype Ghouta-82 or Basel-2 to get higher yield of maize and we recommend to perform soil solarization for 45 days before sowing and to apply 20 t ha^{-1} of compost before soil solarization to improve soil fertility and soil organic matter.

Key words: Soil solarization, organic fertilization, yield and quality, maize, soil chemical properties

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop grown in Syria. The greatest potential for maize production can only be fully realized with adequate nutrients application. Maize ranks among the world's three most important cereals and is a major staple food in many tropical and sub-tropical countries of the world.

Hegde (1998) reported that the use of costly chemical fertilizers can be minimized or replaced by the use of locally available organic manures. Furthermore, integrated use of organic and inorganic manures sustains the productivity of soil and crops in an integrated cropping system. This approach restores and sustains soil health and productivity in the long run, besides meeting the nutritional needs of crops (Satyajeet *et al*., 2007). Maintenance of high crop yields under intensive cultivation is possible only through the use of fertilizers. However, the use of inorganic fertilizers alone has not been helpful under intensive agriculture, because it aggravates soil degradation (Sharma and Mittra, 1991). The degradation is brought about by loss of organic matter which consequently results in soil acidity, nutrient imbalance and low crop yields.

Nutrients contained in organic manures are released more slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect (Sharma and Mittra, 1991). Improvement of environmental conditions and public health concerns as well as the need to reduce cost of fertilizing crops are also important reasons for advocating increased use of organic materials (Seifritz, 1982). Application of organic manures also improves the soil physical and microbial properties (Belay *et al*., 2001).

Soil solarization or "solar heating" is a non-chemical disinfestation practice that may serve as a component of a sustainable IPM programme. Solarization effectively controls a wide range of soil-borne pathogens, insects and weeds. Soil solarization is based on the exploitation the solar energy for heating wet soil mulched with transparent PE sheets to 40-55°C in the upper soil layer. Thermal killing is the major factor involved in the pest control process, but chemical and biological mechanisms are also involved. The efficacy of the thermal killing is determined by the values of the maximum soil temperature and amount of heat accumulated (duration x temperature). The use of organic amendments (manure, crop residues) together with soil solarization (biofumigation) elevates the soil temperature by 1-3°C and improves pest control due to a generation and accumulation of toxic volatiles.

Soil solarization using polyethylene (0.05 or 0.10 mm thickness) for more than 40 days recorded significant levels of available NPK in the soil compared with no soil solarization (Chandrakumar, 2002). Adding compost manure resulted in increasing soil content of NPK and organic matter (Eghball, 2000). Loecke *et al*. (2004) found that maize crop grown under compost fertilizers gave 10% increase in grain yield as compared with other sources of organic manures. El-Gedwy (2007) cited that adding 60 kg of nitrogen per hectare in the form of organic manure gave higher yield and yield components of maize crop comparing with no organic manure. El-Gizawy (2009) revealed that growth parameters, grain yield and yield components of maize were increased with increasing the rate of nitrogen fertilization upto 60 kg ha^{-1} in the form of organic manure.

The main objective of this research was to study the effect of soil solarization and organic manure on productivity of maize and soil chemical properties.

MATERIALS AND METHODS

Materials: This research was conducted in Abu-Jarash farm at the Faculty of Agriculture, Damascus University, Syria during March of the growing season 2013, to evaluate the effect of organic manure treatments (without organic manure, adding organic manure at the rate of 20 t ha^{-1} of compost before sowing the crop by 45 days) and soil mulching treatments (without soil mulching, soil mulching using transparent polyethylene for 45 days) on grain yield of some maize genotypes (Basel-1, Basel-2, Ghouta-1, Ghouta-82 and Local white) obtained from General Commission for Scientific Agricultural Research-Syria and soil chemical properties.

Experimental method: The experiment was laid out according to split-split plot design, where organic manure treatments occupied split-split plots, soil solarization treatment occupied split plots and maize genotypes in main plots, with three replications.

The soil at experimental site was loam soil with higher content of nitrogen (0.13%), phosphorus (28.6 ppm), potassium (315 ppm) and organic matter (2.03%). The temperature prevailed during soil solarization (March-April 2013) was moderate to high and the total rainfall received during the first three months of the growing season-2013 was (94.60 mm), the crop was raised under irrigated conditions. The composition of added compost (1.4:0.50:0.75% of NPK, respectively). The land in the experimental site was ploughed three times to crush soil particles and eradicate weeds in the field, compost was added and mixed with the soil according to treatments, then the land was irrigated to fasten decomposition of organic manure before starting soil solarization.

The prepared land was covered according to treatments with polyethylene plastic sheet with 0.05 mm thickness, the soil in each plot was covered tightly for 45 days from 15 March, 2013 till 30 April, 2013. Maize seeds of different studied genotypes were sown during the first week of May-2013, each split-split plot contain 6 rows, at a distance of 70 cm between rows and 25 cm between seeds within each row, the size of each plot was 4.2×2.00 m = 8.40 m^2). Required observations were recorded i.e. grain yield (t ha^{-1}), stover yield (t ha^{-1}), total nitrogen and organic matter content in the soil after harvesting maize crop.

Data analyzed: The data were collected and subjected to statistical analysis using the statistical program SAS-9 to calculate Least Significant Differences (LSD) at 5% level of significance among studied variables.

RESULTS AND DISCUSSION

Effect of soil solarization and organic manure on maize productivity

Grain yield (t ha^{-1}): The statistical analysis of the results furnished in Table 1 clearly indicated to significant differences ($p<0.05$) among maize genotypes and studied treatments in the mean value of grain yield. The genotype Ghouta-82 recorded significantly the highest mean value of grain yield (7.99 t ha^{-1}) and was closely followed by the genotype Basel-2 (7.12 t ha^{-1}), whereas the genotype Baladi recorded the lowest mean value of grain yield (4.85 t ha^{-1}). There was a significant differences among soil solarization treatments, the highest mean value of grain yield was recorded under soil solarization (6.79 t ha^{-1}) as compared with no solarization (5.65 t ha^{-1}). There was a significant differences among organic manure treatments, the highest mean value of grain yield was recorded under adding organic manure (6.60 t ha^{-1}) as compared with no organic manure (5.79 t ha^{-1}). Increasing grain yield under soil solarization and adding organic manure treatments as compared to no soil solarization and without adding organic manure may be due to increasing yield components like number of grains per cob and 100 kernel weight, these results are in agreement with the findings of Loecke *et al.* (2004), El-Gedwy (2007) and El-Gizawy (2009) in maize crop. The release of nutrients from adding organic manures resulted in improving soil physical and chemical properties especially nitrogen and organic matter content of the soil, which helped in increasing grain yield of maize crop. The results did not show any significant differences in grain yield in the interaction between maize genotypes and soil solarization treatments and maize genotypes and organic manure treatments. Whereas, significant differences were observed in the interaction between soil solarization and organic manure treatments, the highest mean value of

Table 1: Effect of sol solarization and organic manure on grain yield of the studied maize genotypes

	Without soil solarization			With soil solarization			
Genotype	Non organic manure	Organic manure	Mean	Non organic manure	Organic manure	Mean	Total mean
Basel-1	4.15	5.84	4.99	4.75	6.97	5.86	5.43
Basel-2	5.20	7.42	6.31	6.66	9.20	7.93	7.12
Ghouta-1	4.09	6.12	5.11	5.06	7.64	6.35	5.73
Ghouta-82	6.68	8.18	7.43	7.58	9.50	8.54	7.99
Baladi	3.38	5.42	4.40	4.89	5.69	5.29	4.85
Mean	4.70	6.60	5.65	5.79	7.80	6.79	6.22
Variables	G	S	O	S×G	O×G	O×S	O×S×G
LSD (5%)	1.45	0.39	0.38	ns	ns	0.75	ns

ns: Non-significant at 95% level of significance, G: Genotype, S: Soil solarization, O: Organic manure

Table 2: Effect of sol solarization and organic manure on stover yield of the studied maize genotypes

	Without soil solarization			With soil solarization			
Genotype	Non organic manure	Organic manure	Mean	Non organic manure	Organic manure	Mean	Total mean
Basel-1	6.16	7.80	6.98	6.73	8.90	7.82	7.40
Basel-2	7.13	9.47	8.30	8.57	11.10	9.83	9.07
Ghouta-1	6.00	8.03	7.02	7.00	9.53	8.27	7.64
Ghouta-82	8.57	9.80	9.18	9.47	11.47	10.47	9.83
Baladi	5.30	7.20	6.25	6.60	8.30	7.45	6.85
Mean	6.63	8.46	7.55	7.67	9.86	8.77	8.16
Variables	G	S	O	S×G	O×G	O×S	O×S×G
LSD (5%)	1.42	0.44	0.37	ns	ns	0.79	ns

ns: Non-significant at 95% level of significance, G: Genotype, S: Soil solarization, O: Organic manure

grain yield were noticed under soil solarization with adding organic manure treatment (7.80 t ha^{-1}) as compared with no soil solarization and without adding organic manure treatments (4.70 t ha^{-1}).

Stover yield (t ha^{-1}): The statistical analysis of the results presented in Table 2 clearly indicated to significant differences ($p<0.05$) among maize genotypes and studied treatments in the mean value of stover yield. The genotype Ghouta-82 recorded significantly the highest mean value of stover yield (9.83 t ha^{-1}) and was closely followed by the genotype Basel-2 (6.85 t ha^{-1}).

There was a significant differences among soil solarization treatments, the highest mean value of stover yield was recorded under soil solarization (8.77 t ha^{-1}) as compared with no solarization (7.55 t ha^{-1}). There was a significant differences among organic manure treatments, the highest mean value of stover yield was recorded under adding organic manure (8.46 t ha^{-1}) as compared with no organic manure (7.67 t ha^{-1}). Increasing stover yield under soil solarization and adding organic manure treatments as compared to no soil solarization and without adding organic manure may be due to improving growth parameters like plant height, leaf area and total dry matter accumulation in the plant, these results are in agreement with the findings of El-Gedwy (2007) and El-Gizawy (2009) in maize crop. The release of nutrients from adding organic manures resulted in improving soil physical and chemical properties especially nitrogen and organic matter content of the soil, which helped in increasing stover yield of maize crop. The results did not show any significant differences in stover yield in the interaction between maize genotypes and soil solarization treatments and maize genotypes and organic manure treatments. Whereas, significant differences were observed in the interaction between soil solarization and organic manure treatments, the highest mean value of stover yield were noticed under soil solarization with adding organic manure treatment (9.86 t ha^{-1}) as compared with no soil solarization and without adding organic manure treatments (6.63 t ha^{-1}).

Effect of soil solarization and organic manure on soil chemical properties

Total nitrogen contents in the soil (%): The statistical analysis of the results furnished in Table 3 showed no significant differences ($p<0.05$) among maize genotypes in the mean value of total nitrogen content in the soil. However, the plots grown with genotype Basel-1 recorded the highest mean value of total nitrogen content (0.145%), whereas the lowest mean value of total nitrogen content was observed in the plots grown with the genotype Baladi (0.137%). There was a significant differences among soil solarization treatments, the highest mean value of total nitrogen content was recorded under soil solarization (0.145%) as compared with no solarization (0.136%). Soil solarization lead to fastening the rate of organic matter in the soil due to raising in soli temperature, which resulted in releasing the nutrients especially NO_3-N and NH_4-N in the soil,

Table 3: Effect of sol solarization and organic manure on total nitrogen content in the soil after harvesting maize crop

	Without soil solarization			With soil solarization			
Genotype	Non organic manure	Organic manure	Mean	Non organic manure	Organic manure	Mean	Total mean
Basel-1	0.127	0.150	0.138	0.143	0.160	0.152	0.145
Basel-2	0.127	0.150	0.138	0.130	0.150	0.140	0.139
Ghouta-1	0.130	0.143	0.137	0.133	0.163	0.148	0.143
Ghouta-82	0.127	0.147	0.137	0.130	0.150	0.140	0.138
Baladi	0.110	0.150	0.130	0.130	0.157	0.143	0.137
Mean	0.124	0.148	0.136	0.133	0.156	0.145	0.140
Variables	G	S	O	S×G	O×G	O×S	O×S×G
LSD (5%)	ns	0.008	0.006	ns	ns	0.013	ns

ns: Non-significant at 95%, G: Genotype, S: Soil solarization, O: Organic manure

Table 4: Effect of sol solarization and organic manure on organic matter content in the soil after harvesting maize crop

	Without soil solarization			With soil solarization			
Genotype	Non organic manure	Organic manure	Mean	Non organic manure	Organic manure	Mean	Total mean
Basel-1	1.94	2.04	1.99	1.92	2.07	2.00	1.99
Basel-2	2.00	2.06	2.03	1.95	2.24	2.10	2.06
Ghouta-1	1.97	2.02	2.00	2.01	2.10	2.06	2.03
Ghouta-82	1.96	2.15	2.06	1.98	2.28	2.13	2.09
Baladi	1.82	2.05	1.94	1.93	2.10	2.01	1.98
Mean	1.94	2.06	2.00	1.96	2.16	2.06	2.03
Variables	G	S	O	S×G	O×G	O×S	O×S×G
LSD (5%)	0.034	0.015	0.021	0.057	0.065	0.036	0.102

G: Genotype, S: Soil solarization, O: Organic manure

these results in conformity with the results of Chandrakumar (2002). There was a significant differences among organic manure treatments, the highest mean value of total nitrogen content was recorded under adding organic manure (0.148%) as compared with no organic manure (0.133%). Increasing total nitrogen content under adding organic manure treatments as compared to no organic manure may be due to releasing the nutrients especially NO_3-N and NH_4-N in the soil from added organic manure, these results in conformity with the results of Eghball (2000) and Belay *et al*. (2001).

The results showed no significant differences in total nitrogen content in the interaction between maize genotypes and soil solarization treatments and maize genotypes and organic manure treatments. Whereas, significant differences were observed in the interaction between soil solarization and organic manure treatments, the highest mean value of total nitrogen content were noticed under soil solarization with adding organic manure treatment (0.156%) as compared with no soil solarization and without adding organic manure treatments (0.124%). These results in conformity with the results of Pradeep (2003) who declared that adding organic manure before soil solarization resulted in availability of nutrients comparing with adding organic manure after soil solarization and control.

Organic matter content in the soil (%): The statistical analysis of the results presented in Table 4 showed significant differences ($p<0.05$) among maize genotypes in the mean value of organic matter content in the soil. However, the plots grown with genotype Ghouta-82 recorded the highest mean value of organic matter content (2.09%), whereas, the lowest mean value of total nitrogen content was observed in the plots grown with the genotype Baladi (1.98%).

The organic matter content was significantly the highest under soil solarization treatments (2.06%) as compared with no solarization (2.00%). Soil solarization lead to improving soil physical, chemical and biological properties, which resulted in better growth of plants roots and microorganisms in the soil decomposed with the time and added organic matter to the soil.

There was a significant differences among organic manure treatments, the highest mean value of organic matter content was recorded under adding organic manure (2.06%) as compared with no organic manure (1.96%). Adeniyan *et al*. (2011) cited that adding organic manures to the soil has improved soil chemical properties comparing with no adding of organic manures and decreased pH, increased available nitrogen, phosphorous and potassium, which resulted in increasing the productivity of maize crop.

There was significant differences in organic matter content of the soil in the interaction between maize genotypes and soil solarization treatments and maize genotypes and organic manure treatments, the genotype Ghouta-82 recorded the highest mean value of organic matter content in the soil (2.13 and 2.15%, respectively). The results indicated to significant differences in organic matter content in the interaction between soil solarization and organic manure treatments, the highest mean value of organic matter content were noticed under soil solarization with adding organic manure treatment (2.16%) as compared with no soil solarization and without adding organic manure treatments (1.94%). The genotype Ghouta-82 recorded significantly the highest mean value of organic matter content under soil solarization and adding organic manure (2.28%).

CONCLUSIONS

The findings of this research paper showed significant effect of soil solarization and organic manure treatments on grain and stover yield of studied maize genotypes. Therefore, we recommend to grow the genotype Ghouta-82 to get higher productivity of maize crop under Damascus city conditions, we also recommend to perform soil solarization before maize cultivation by 45 days and adding composted organic manure at the rate of 20 t ha^{-1} before soil solarization to improve soil chemical properties especially total nitrogen and organic matter content of the soil.

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