J. Agric. Sci. Mansoura Univ., 25 (1): 53 - 69, 2000.

EFFECT OF SOIL SOLARIZATION AND CHICKEN MANURE ADDITION ON GROWTH AND NITROGEN CONTENT OF CORN PLANT

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ABSTRACT

Two field experiments were conducted at Hada Al-Sham Agricultural Experimental Station, King Abdulaziz University during the two sowing dates (Fall, 1994 and Spring, 1995) to study the effect of soil solarization (mulching field soil with clear plastic) and soil amendment with chicken manure, at the rate of 0, 10, 20 and 40 t/ha, on total dry matter accumulation and its parts (leaf, stem, ear, and tassel) as well as nitrogen content in the different plant parts and nitrogen uptake by corn plants during three plant growth stages (vegetative, milky and maturation) of hybrid corn plant (AGA seed 215 cultivar). Soil solarization for six weeks during the Summer 1994, was proceeded the two sowing dates of corn plantation. Results of the study indicated that the effect of sowing date was highly significant on some parameters. The first sowing date (Fall) has higher values than the second sowing date (Spring) on the following parameters: dry matter production and its parts (stem, ear and tassel), plant height, leaf area, plant and stem nitrogen content and nitrogen uptake. Total dry matter and its parts (leaf, stem and ear), leaf area, plant height and nitrogen uptake were increased with the advancement of the plant growth. However, plant nitrogen content and its parts and tassel dry matter were decreased with the advancement of the plant growth. Total dry matter, plant height, tassel nitrogen content and nitrogen uptake were higher in solarized than non-solarized soil. On the other hand, there was no significant difference between dry matter of plant parts, leaf area and plant nitrogen content and its parts (leaf, stem and ear) due to soil solarization. There were no significant differences between all studied parameters due to chicken manure treatments except for tassel nitrogen content. It was increased with the increase of the rates of chicken manure.

INTRODUCTION

Soil solarization is one of the methods of soil disinfestation and it is the newest approach that is based on solar heating of the soil by covering (tarping or mulching) the soil with transparent polyethylene during the hot season or when appropriate climatic conditions prevail. The use of transparent polyethylene mulching is a way of capturing solar energy to heat the soil under field conditions, by which the soilborne pests are killed. Polyethylene soil cover only enables better solarization when the soil is wet, making a tremendous improvement in the process of soilborne pest control (Katan et al. 1976).

Soil mulching with transparent polyethylene is widely used to increase soil temperatures. Dubey (1992) indicated a maximum increase of temperature in solarized soil up to 11 C. Another report by Chellimi et al. (1994), reported an increase in solarized soil of 8.8, 7.8 and 4.9 C at soil depths of 5, 15 and 25 cm over non-solarized soil, respectively. Similar results were indicated by

Habeebrrahman and Hosmani (1996). Polyethylene sheets application was reported to warm the soil beneath the sheets and conserve soil moisture by reducing water loss by evaporation from the surface soil (Adetunji, 1994).

Courter and Debker (1964), Takatori et al. (1964), Hopen (1965), Vandenberg and Tiessen (1972), Katan et al. (1976), Stapleton et al. (1985) Ghini et al. (1993), Ahmad et al. (1996), Keinath (1996) and Lopez Herrera et al. (1997) have shown that soil mulching increases yields, promotes early maturing of certain vegetables, and controls soilborne plant pathogens and weeds.

Ahmad et al. (1996) observed that growth of corn crop planted in solarized plots was better and it yielded one to three times more grains than non-solarized plots.

Stapleton et al. (1985) reported an increase in plant growth following soil solarization. They reported that there was a significant correlation between plant growth (chinese cabbage) and soil concentration of NO_3^--N and NO_3^--N + NH_4^+-N in loamy soil and NO_3^--N + NH_4^+-N in the fine sandy loamy soil. However, they reported that fresh and dry weights of plants were greater when grown in solarized than in non-solarized soil. They also suggested that combined solarization and fertilizer application resulted in greater plant growth responses than in solarized but not fertilized soil. Similar results were found by Adetunji (1994) , Arora (1998) and Arora and Yaduraju (1998).

Disease and weed control by soil solarization was usually accompanied by an increase in yield and quality (Pullman et al., 1980; Katan, 1981; Sitti et al., 1982; Katan et al., 1983; Rubin and Benjamin, 1983; Stevens et. al., 1990; Al-Masoom et al., 1993; Bourbos and Skoudridakis, 1996; Habeebrrahman and Hosmani, 1996; Ismail et al., 1997; Lopez-Herrera et al. 1997 and Arora and Yaduraju, 1998). Bourbos and Skoudridakis (1996) indicated that the yield of tomato was increased in solarized soil by 112.4% in comparison with non-solarized control. They also observed no infection with Verticillium wilt in greenhouse tomatoes planted in solarized soil. Campiglia et al. (1998) found out that weed density and total biomass using the solarization method were decreased up to 91% that resulted in an increase in the growth and yield of head lettuce up to 106%.

The effect of soil solarization combined with soil organic amendment on plant growth was studied by Keinath (1996). He found that incorporating cabbage residue into mulched soil increased growth and yield of watermelon. In another study by Gamliel and Stapleton (1997) they determined that combining chicken and cruciferous residues during solarization gave better control of soil pathogens and higher yield of lettuce and tomatoes than control or each treatment alone.

This research has an important application at the local level, especially for the environmental conditions of the Kingdom of Saudi Arabia. High intensity of solar radiation and very high temperature during the summer provide the appropriate conditions for efficient solarization approach. This approach of soilborne control reduces the use of pesticide and herbicide and their pollutant effect on the crop, soil, and groundwater. In addition, solarization will increase the decomposition of organic matter which will improve the availability of nutrients for plant and increase the crop yield.

The objective of this research is to determine the effect of soil solarization and chicken manure as a soil amendment on corn dry matter accumulation, plant height, leaf area and nitrogen contents of different plant parts during three plant growth stages (vegetative, milky and maturation) under two sowing dates of corn plant.

MATERIALS AND METHODS

Two field experiments were conducted at Hada Al-Sham Agricultural Research Station, King Abdulaziz University during two sowing dates (Fall 1994 and Spring 1995) to study the effect of soil solarization and four treatments of chicken manure as a soil amendment on total dry matter and its parts (leaf, stem, ear, and tassels) as well as nitrogen content in different plant parts and nitrogen uptake by the plant during the three growth stages (vegetative, milky and maturation) of corn plant. Each of the two experiments was conducted in complete randomized block design with three replications in 2x4x3 factorial arrangement.

Each experiment included eight treatments; two treatments of solarization (solarized and non-solarized soil) and four treatments of chicken manure (0, 10, 20 and 40 t/ha). The treatments were randomly distributed in three replicates. All studied parameters were recorded during each of the plant growth stages.

For preparation of the experimental field, the site was tilled, leveled and divided into 24 plots, at three by three meters dimension. The different experimental rates of chicken manure under the study were applied to the soil.

A data acquisition system was applied to record continuous observations for the different experiment variables: soil temperature at three different soil depths (5, 10 and 25 cm), air temperature and relative humidity. Different variable sensors were located at the decided depths through soil layers and at two meter height above the soil surface. A data logger was connected with all the above variable sensors for continuous recording, during the solarization period (31/7 to 15/9/1994). Recorded air and soil temperatures are presented in Table (1).

Soil was flooded with irrigation water to achieve good heat conductivity through the soil profile. A 100 µ clear polyethylene sheet was applied to cover half of the experimental area, while the other half was left uncovered to serve as control.

After the solarization experiment (when the plastic sheet was removed), the land was fertilized with triple superphosphate (46% P_2O_5) and potassium sulphate (50% K_2O). Both fertilizers were applied at rate of 400 kg/ha as a single dose. Urea (46% N) was applied side-dressed at four equal doses at rate of 400 kg/ha in 15 days intervals during the growth period. In this respect, the first dose was applied 15 days from sowing, whereas the last dose was applied 60 days after sowing.

Table 1. Average monthly recorded air and soil temperatures during

Temp. range	Soil depth (cm)	Soil temperature (C)				Air temperature (C)	
		August		September			
		Solarized*	Non-sol.	Solarized	Non-sol.	Aug.	Sept.
Minimum	5	28.5	27.0	29.0	33.5	18.9	20.0
	10	24.8	23.0	33.9	40.1		
	25	26.4	33.9	23.7	38.2		
Maximum	5	68.6	52.2	62.4	50.7	47.0	47.7
	10	51.6	45.2	53.5	49.0		
	25	50.4	38.7	51.5	41.8		
Mean	5	48.5	39.8	48.2	42.1	32.9	32.7
	10	38.2	34.1	43.7	44.5		
	25	38.4	36.3	37.6	40.0		

*** Soil was solarized from July 31 – September 15, 1**

soil solarization experiment.

The experimental land was irrigated at sowing, and then irrigation was applied according to the crop water requirement. Each of the 24 bordered plots was divided into four ridges in 75 cm distance. Hills within ridges were 30 cm apart. At sowing, three corn seeds (AGA seed 215 cultivar) were planted per hill and after a full emergence, they were thinned to a single seedling per hill.

Three plant samples were collected during the growth period of the corn plants as follows: the first samples (vegetative growth stage), the second (Milky) and the third samples (maturation). In each sample, five plants (1.2 m^2) were harvested from each plot and their mean height, total leaf area ($cm^2/1.2\ m^2$) and total dry matter ($g/1.2\ m^2$) and its parts (leaf, stem, ear and tassel) were measured. In addition, plant nitrogen content and its parts was measured using Kejeletic Auto 1030 Analyzer (Bremner, 1965). Statistical analysis was performed using M-STAT program.

RESULTS AND DISCUSSION

Total dry matter accumulation

The average values of total dry matter and its parts (leaf, stem, ear and tassel) in the second sowing date (Spring) were lower than those of the first sowing date (Fall)(Table 2). The difference in total dry matter and its parts between the first and second sowing date was possibly due to the release of nutritive elements, particularly nitrogen, phosphorus and potassium, from the decomposition of chicken manure in the soil during the solarization that preceded the first sowing date as observed by Hinesly et al. (1979), Stapleton et al. (1985), Arora (1998) and Arora and Yaduraju (1998). The plant-nitrogen content, nitrogen uptake and leaf area (Tables 2 and 3) were higher in the Fall than the Spring sowing date that might have increased total dry matter of corn plant. The direct exposure of soil (solarized and non-polarized) to the sunlight during the summer for pest control might have contributed to the difference observed in dry matter production, as indicated by Grooshevoy (1939), Raghaven (1964) and Katan (1981). As early as 1939, Grooshvoy, a Russian plant pathologist, succeeded in establishing solar heating of the soil as a means of pathogen control. Unfortunately, plastic technologies were not available at that time. Also, the difference in the environmental conditions between the two sowing dates, in terms of temperature (Mack et al. 1966) and light intensity (Leonard and Martin, 1963) might have contributed to the difference observed in the total dry matter production.

Table 2. The dry matter accumulation and their parts (leaf, stem, ear, and tassel), leaf area and plant height and their test of significance at two sowing dates of corn plant.

Variable		Plant height (cm)	Leaf area (cm^2)	Dry matter (g/1.2 m^2)				
				Leaf	Stem	Ear	Tassel	Plant
Sowing date	1	151.692 A*	8762.243A	133.79 A	301.77 A	353.12 A	38.71 A	827.39 A
	2	104.271 B	7010.797 B	113.75 A	267.08 B	118.90 B	28.52 B	528.25 B
LSD		2.995	803.697	NS	32.37	27.29	2.81	31.51
Growth stage	1	41.715 C	4170.32 B	33.95 B	26.39 B			60.34 C
	2	163.479 B	9915.87 A	165.61 A	343.26 A	112.03 B	39.65 A	660.05 B
	3	178.750 A	9573.38 A	171.74 A	483.62 A	359.99 A	27.58 B	1042.93 A
LSD		5.194129	1392.76	18.52	158.32	27.29	2.81	54.61
Soil solarization	1	132.460 A	7871.32 A	126.48 A	294.11 A	242.26 A	37.71 A	700.56 A
	2	123.503 B	7901.72 A	121.06 A	274.76 A	229.79 A	29.52 A	655.13 B
LSD		2.995	NS	NS	NS	NS	NS	31.51
Manure	1	128.139 A	7540.49 A	116.98 A	332.59 A	254.88 A	31.65 A	736.10 A
	2	125.722 A	7200.55 A	121.00 A	324.97 A	220.09 A	35. 32 A	701.38 A
	3	128.778 A	8472.88 A	124.81 A	234.89 A	225.93 A	30.64 A	616.27 A
	4	129.286 A	8332.16 A	132.28 A	245.25 A	243.16 A	36.85 A	657.54 A
LSD		NS	NS	NS	NS	NS	NS	NS

Sowing date 1 = Fall, 2 = Spring.
Soil solarization 1 = Solarized and 2 = Non-solarized soil
Growth stage 1 = Vegetative, 2 = Milky and 3 = Maturation. Chicken manure (t/ha) 1 = 0, 2 = 10, 3 20 and 4 = 40.
LSD = Least significant difference at 0.05
*** Values holding the same letter are significantly at 0.05 not different**
NS = Not significant

Average values of total dry matter and its parts (leaf, stem and ear) were the lowest in the first growth stage (vegetative) followed by the second (milky) and the third (maturation), in an increasing order. On the other hand tassel dry matter was decreased with the advancement of plant growth stages (Table 2).

Soil solarization increased the total dry matter production (569.1 g/1.2 m^2) over non soil solarization (514.6 g/1.2 m^2) (Table 2). The increase due to solarization over non-solarization treatment might be attribuyed to control of soilborne pests and weeds which compete with the crop for available nutrients and water. Similar results were reported by Stevens et. al. (1990), Al-Masoom et al. (1993), Ghini et al. (1993), Bourbos and Skoudridakis, (1996) Habeebrrahman and Hosmani, (1996), Ismail et al. (1997), Lopez-Herrera et al. (1997) and Arora and Yaduraju, (1998). It has been observed that solarized soil has less weed population than non-solarized soil (data to be published by the authors). On the other hand there was no significant difference in the leaf, stem, ear and tassel dry matter due to soil solarization.

There was no significant difference in the total dry matter production and its parts due to the application of the chicken manure (Table 2). Chicken manure as a soil amendment has no significant effect on all studied parameters (Table 2 and 3). These results contradict the observations of other researchers who indicated an increase of plant growth when animal manures were applied as a soil amendment (Maynard, 1994; Jackson and Smith, 1997; Gamliel and Stapleton, 1997 and Ritz et al., 1997). These results might attributed to the role of N P K fertilization supplied as triple superphosphate, potassium sulphate and Urea at 400 kg\ha that gave enough requirment of nutrients for the corn plants and hence masked the influence of chicken manure.

Table 3. Plant nitrogen content and its parts (leaf, stem, ear, and tassel) and nitrogen uptake of two sowing dates of corn plant and their test of significance.

Variable		Nitrogen (g/kg)					Nitrogen uptake
		Leaf	Stem	Ear	Tassel	Plant	(g/plant)
Sowing date	1	2.48 A	2.11 A	1.93 A		2.01 A	2.19 A
	2		1.51 B	1.72 B	1.44 A	1.26 B	1.37 B
LSD		NS	0.08	0.19	NS	0.08	0.13
Growth stage	1	3.18 A	3.01 A			1.94 A	0.35 C
	2	2.39 B	1.31 B	2.39 A	1.87 A	1.59 B	2.25 B
	3	1.70 C	1.11 C	1.26 B	1.03 B	1.38 C	2.74 A
LSD.		0.17	0.13	0.19	0.14	0.15	0.23
Soil solarization	1	2.57 A	1.79 A	1.81 A	1.58 A	1.67 A	1.90 A
	2	2.48 A	1.83 A	1.85 A	1.32 B	1.61 A	1.661 B
LSD		NS	NS	NS	0.14	NS	0.13
Manure	1	2.49 A	1.73 A	1.75 A	1.32 B	1.58 A	1.73 A
	2	2.52 A	1.81 A	1.90 A	1.40 B	1.68 A	1.73 A
	3	2.59 A	1.86 A	1.77 A	1.33 B	1.67 A	1.89 A
	4	2.51 A	1.84 A	1.89 A	1.75 A	1.64 A	1.78 A
LSD		NS	NS	NS	0.28	NS	NS

Sowing date 1 = Fall, 2 = Spring. NS = Not significant,
Soil solarization, 1 = Solarized and 2 = Non-solarized
Growth stage 1 = Vegetative, 2 = Milky and 3 = Maturation.
Chicken manure (t/ha), 1 = 0, 2 = 10, 3 = 20 and 4 = 40
LSD = Least Significant Difference at 0.05
*** Values holding the same letter are significantly at 0.05 not differ**

The effect of different plant growth stages on total dry matter and its parts (leaf, stem and ear) by two successive sowing dates of corn plant is shown in Fig. (1). Total dry matter and its parts were significantly increased with the advancement of the plant growth, however, the first dominated the second sowing date.

The effect of soil solarization on the total dry matter production by two successive sowing dates of corn plant is shown in Fig. (2). Total dry matter was significantly higher in the soil solarization than in non-soil solarization treatment in both sowing dates. Similar results were indicated by Ahmad et al. (1996).

Plant height

The average value of plant height in the second sowing date (104.3 cm) was significantly lower than the first sowing date (151.7 cm) (Table 2). The average value of plant height was the lowest in the first stage (vegetative) (41.7 cm) followed by second (milky) (163.5 cm) and the third (maturation) (178.8 cm) in an increasing order (Table 3).

The effect of different plant growth stages on plant height at two sowing dates of corn plant are shown in Fig.(3-A). Plant height was significantly higher in the first than the second sowing date in all growth stages of the corn plant.

The effect of soil solarization on plant height at different plant growth stages is shown in Fig. (4-A). Plant height was significantly higher in solarized than non-solarized soil in all plant growth stages. Similar observations were reported by Lopez-Herrera et al. (1997).

The effect of increasing rate of chicken manure in combination with the three plant growth stages on plant height is shown in Fig. (4-B). There was a gradual increase in plant height with the increase of the chicken manure rates. However, the third growth stage had the highest plant height followed by the second and the first, in a decreasing order.

Plant growth stages

Fig.3. Effect of plant growth stages on : A, Plant height and B, Leaf area under two successive crops of corn plant.

Plant growth stages
G1= Vegetative
G2= Milky

Sowing date
SD1 = Fall
SD2= Spring

G3= Maturation

fig 4

Leaf Area

The average value of leaf area in the second sowing date (7010.8 $cm^2/1.2m^2$) was significantly lower than the first sowing date (8762.2 $cm^2/1.2m^2$) (Table 2). The average value of the leaf area was significantly the lowest in the first stage (vegetative) (4170.3 $cm^2/1.2m^2$) followed by the third (maturation) (9573.4 $cm^2/1.2m^2$) and the second (milky) (9915.9 $cm^2/1.2m^2$), in an increasing order (Table 2). There was no significant difference in the leaf area due to the soil solarization and manure treatments (Table 2).

The interaction of the different plant growth stages with the two sowing dates of corn plant on leaf area is shown in Fig. (3-B). Leaf area was significantly higher in the first than the second sowing date. The second growth stage, however, had the highest leaf area followed by the third then the first corn plant growth stage.

Plant-nitrogen content

The average value of plant-nitrogen content and its parts (stem and ear) in the second sowing date was significantly lower than the first sowing date. The average value of plant-nitrogen content and its parts was decreased with the advancement of the plant growth. On the other hand, there were no significant differences in the plant-nitrogen content and its parts due to soil solarization and chicken manure treatment. However, tassel-nitrogen content was increased with the increase of chicken manure rates and in solarized over non-solarized soil Table (3).

The effect of different plant growth stages on plant-nitrogen content and its parts (stem and ear) at two sowing dates is shown in Fig. (5). Plant-nitrogen content and its parts were decreased with the advancement of the plant growth stages. However, the first dominated the second sowing date.

The effect of soil solarization on stem-nitrogen content at two sowing dates of corn plant is shown in Fig. (6-A). There was no significant difference in stem-nitrogen content due to the solarization treatment. However, stem-nitrogen content was higher in the second than in the first sowing date. The effect of chicken manure treatment with the three plant growth stages on stem-nitrogen content were shown in Fig. (6-B). There was a gradual increase in stem nitrogen content of corn plants with the increase of chicken manure rates. However, the first plant growth stage, has the highest stem-nitrogen content followed by the second and the third in decreasing order.

The effect of the interaction of chicken manure rate with soil solarization on tassel-nitrogen content is shown in Fig. (7). Nitrogen-tassel content was significantly higher in the solarized than the non-solarized soil treatment. The fourth treatment of chicken manure (40 t/ha) had the highest tassel-nitrogen content followed by the second (10 t/ha), the third (20 t/ha) and the control (0 t/ha) in a decreasing order.

Nitrogen uptake

The average value of nitrogen uptake in the second (1.4 g/plant) was significantly lower than the first sowing date (2.2 g/plant). The average value of nitrogen uptake in the non-solarized (1.7 g/plant) was significantly lower than the solarized soil (1.90 g/plant) (Table 3). Similar results were observed by Ghini et al. (1993), Adetunje (1994), Arora (1998) and Arora and Yaduraju (1998).

Fig5

Fig6

The average value of nitrogen uptake was significantly the lowest in the first stage (vegetative) (0.35 g/plant), followed by second (milky) (2.25 g/plant) then the third (maturation) (2.74 g/plant), in an increasing order (Table 3).

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تأثير تشميس التربة و إضافة زرق الدجاج إليها على نمو الذرة الشـامية (*Zea maize* L.) و محتواها النيتروجيني

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أقيمت تجربتان حقليتان في مزرعة الأبحاث الزراعية التابعة لجامعة الملك عبر العزيز بهدى الشام خلال موعدين زراعيين (خريف ١٩٩٤ و ربيع ١٩٩٥) لدراسة تأثير تشميس التربة (تغطية التربة الحقلية بشرائح البلاستيك الشفاف) و التسميد بمعاملات مختلفة من زرق الدجاج (٠, ١٠, ٢٠ و ٤٠ طن للهكتار) على الوزن الكلي للمادة الجافة و أجزائها (أوراق, سيقان, كيزان و شوشة), و كذلك المحتوى النيتروجيني للنبات و أجزائه و النيتروجين الممتص بواسطة نبات الذرة الشامية خلال مراحل النمو المختلفة (خضري, اللبني و النضج) لموعدين زراعيين متتاليين للذرة الشامية (صنف أجا سييد ٢١٥). و من أبرز ما أظهرته هذه الدراسة أن مواعيد الزراعة كان لها تأثيرا معنويا عاليا. حيث أن موعد الزراعة الخريفية كان أعلى من موعد الزراعة الربيعية في الصفات التالية: الوزن الكلي للماد الجافة و أجزائها (السيقان, الكيزان و الشوشة), طول النبات, مساحة الأوراق, المحتوى النيتروجيني للنبات الكامل و الساق و النيتروجين الممتص بواسطة النبات. و قد لوحظ زيادة الوزن الكلي للمادة الجافة و أجزائها (أوراق, سيقان, كيزان), مساحة الأوراق, طول النبات و النيتروجين الممتص بواسطة نبات الذرة الشامية مع التقدم في عمر النبات (من مرحلة النمو الخضري إلى مرحلة النضج). في المقابل انخفض المحتوى النيتروجيني للنبات و أجزائه, و الوزن الجاف للشوشة مع التقدم في عمر النبات. كما لوحظ أن الوزن الكلي للمادة الجافة, طول النبات و النيتروجين الممتص بواسطة النبات كانوا أعلى في التربة المشمسة عن غير المشمسة. في المقابل لم يكن هنالك تأثير معنوي لتشميس التربة على الوزن الجاف لأجزاء النبات المختلفة, مساحة الأوراق و المحتوى النيتروجيني لأجزاء النبات المختلفة (أوراق, سيقان و كيزان), و كذلك لم يكن هنالك تأثير معنوي لمعاملات زرق الدجاج على جميع الصفات المدروسة ما عدى المحتوى النيتروجيني للشوشة. حيث زاد المحتوى النيتروجيني للشوشة مع زيادة معدلات زرق الدجاج.