IMPROVING THE GROWTH OF SUNFLOWER PLANTS ON CALCAREOUS SOIL

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Abdel-Rassoul, M.[1]; I.Z. El-Shamey[1]; Amira, M. Hegazi[1] and O.K. Abo El-Atta[1]

[1]*Department of Agric. Botany Fac. of Agric. Ain Shmas Univ. Cairo, Egypt.*

ABSTRACT

Two pot experiments in green house during the years 2001 and 2003 were conducted on sunflower plants *Helianthus annuus* L. and grown under calcareous soil conditions in green house during the years 2001 and 2003. The main objective was investigating the responses of sunflower plants to some treatments tend to improve nutrient status of plants. In the first experiment soil application of chelated microelements to sunflower plants gave the maximum values of plant height and shoots dry weight. These effects were accompanied by increasing P, K, Fe, Zn and Mn concentrations in leaves. Application of S, N and P as mineral acids showed also increase in plant growth and nutrient elements concentrations. In the second experiment localized application of elemental sulphut plus mono calcium phosphate (ES +P) gave the highest values of plant growth parameters followed by microelements and mineral acid treatments respectively. Meanwhile, localized application of ES +P recorded the highest percentage of P and Ca in mesophyll tissues Further more plant growth hormones; GA_3 and IAA were increased. While marked reduction in abscisic acid was detected.

Key words: Calcareous soil, Sunflower, Elemental sulfur, Phosphorous, Mineral acids, Microelements, endogenous phytohormones, X-ray microanalysis.

INTRODUCTION

Calcareous soils are one of the major problems in new reclaimed lands in Egypt. These soils are important for increasing agricultural production. For instance, sunflower, seeds have become a major source of oil. There is a gap between production and consumption of plant oils in Egypt. Increasing the cultivated areas of sunflower crop should be done outside the Nile Valley due to the competition of other main crops. The primary distinction of calcareous soil is that, it contains much greater calcium carbonate ($CaCO_3$) more than other soils. Therefore calcareous soils exerted its effect via ($CaCO_3$) which reduce nutrient availability and chemical reactions that affect the fixation of some nutrients (Khorsandi, 1994). The presence of $CaCO_3$ directly or indirectly affecting the chemistry and availability of nitrogen (N), phosphorous (P), magnesium (Mg), potassium (K), iron (Fe), manganese (Mn) and zinc (Zn), Obreza *et al* (1993). Furthermore, the physical conditions of calcareous soils are poor due to compacting and heavy soil texture. Over the years, attempts were made to improve nutrients availability and soil structure of calcareous soil. These primarily acquired, decreasing soil pH and/or providing substantial quantities of nutritional elements in a suitable form.

The main objective of this study was undertaken to investigate the response of sunflower plants to different nutritional treatments in order to improve nutrient status of plants plant growth, contents of nutrient elements and phytohormones.

MATERIALS AND METHODS

Two pot experiments were conducted on sunflower, *Helianthus annus* L. cv. Vidoc during the years 2001 and 2003 in the greenhouse of Agricultural Botany Department, Faculty of Agric. Ain Shams University.

Calcareous soil collected from El-Nahda, El-Ameria, Alexandria Governorate was used. This soil was air dried, crushed and sieved to pass through 2 mm screen before using. The physical and chemical properties of this soil are shown in Table (1).

Table (1): Physical and chemical properties of the calcareous and non calcareous (loamy) soil.

	Calcareous	Non Calcareous soil
A- Physical analysis		
Soil texture	Loamy sand	Clay
Coarse sand %	42.71	8.15
Fine sand %	35.81	13.50
Silt %	13.42	29.55
Clay %	8.06	48.80
B- Chemical analysis		
$CaCO_3$ %	35.5	5.5
Organic Matter %	0.8	1.36
EC	2.3	1.05
PH	8.2	7.87

First experiment:

Sunflower seeds were sown in pots contain 5 kg soil on April, 23rd 2001 and thinned after 2 weeks to 2 plants /pot. In this experiment appropriate fertilization for calcareous soil was basically applied to all sunflower plants (Table, 2). However, this experiment involved 8 treatments (5 replicates) are listed in details in Table (3).

Sample was taken, at vegetative stage; 10 weeks after sowing, plant height, shoots dry weight, root dry weight and root/shoot ratio were recorded.

Determination of nutrient elements in leaves:

One gram of each leaves sample was wet digested. Fe, Mn, Mg, Cu and Zn were estimated using Atomic Absorption Spectrophotometer (AAS), Unicom 939. K and Ca were determined with flamephotometer. Phosphorus concentration was determined using the molybdenum blue assay (Murphy and Riley, 1962).

Table 2: Basic fertilization of sunflower grown on calcareous soil (A) and non calcareous (clay) soil (B)

Fertilizer	Calcareous soil for firs and second experiment	Non calcareous soil for second experiment
Before sowing		
cow manure	75.5 g/pot	37.5 g/pot
$Ca(H_2PO_4)_2$	194.25 mg/pot	97.12 mg/pot
After sowing		
$(NH_4)_2SO_4$	500 mg N/pot 3 times at 2,4 and 6 weeks after sowing	125 mg N/pot 3 times at 2,4 and 6 weeks after sowing
K_2SO_4	207.5 mg K/pot 2 times with 1st and 2nd doses of N application	207.5 mg K/pot 2 times with 1st and 2nd doses of N application
Chelated microelements	70,50,47 and 26 mg/L of Fe, Zn, Mn and Cu respectively (3 times at 4,6 and 8 weeks after sowing	

Table 3: Treatments of first experiment.

Treatments	Concentration (rate)	Application method	Application time
1- Control	Basic fertilizer (Table 2)		
2- $Ca(H_2PO_4)_2$	0.4 g/L	Foliar spray	3 times at 3, 5 and 7 weeks after sowing
3- Chelated microelements soil appl.	Fe 140 mg/pot Zn 100 mg/pot Mn 94 mg/pot Cu 52 mg/pot	With irrigation water	2 times at 5 and 7 weeks after sowing
4- HNO_3 (0.2%) + H_3PO_4 (0.2%) + H_2SO_4 (0.2%)	200 .ml/pot 200 ml/pot 200 ml/pot	With irrigation water	2 times/ week
5- Phosphorin	107 g/100 g seed	Seed treatment	Directly before sowing
6-Citric acid	100 mg/L	Foliar spray	2 times at 5 and7 weeks after sowing
7- Humic acid	2.5 mg/pot	With irrigation water	4 times at 0,2,4 and 6 weeks after sowing
8- Compost	37.5 g/pot	Mixed with soil	Before sowing

Second experiment:

This experiment aimed to compare the response of sunflower plants to different treatments tends to improve nutrition status of plants. Sunflower seeds were sown in 3 Kg plastic pots (10 seeds /pot) on September 10th 2003. Half number of pots was filled with non calcareous soil collected from Faculty of Agric. Shoubra Elkheima, Kalyobia; (Table, 1) and the other pots filled with calcareous soil. Ten days later, plants were thinned to two plants/pot.

Non calcareous soil was subjected to the recommended fertilization (Table 2), it received the same treatments as follows:

1- Control.
2- Microelements as chelated compounds with irrigation water (Fe, Zn, Mn and Cu at a rate of 84, 60, 56 and 31 mg/ pot, respectively) 2 times, 5 and 7 weeks after sowing.
3- Mineral acids applied with irrigation water (200 mL/pot of 0.2 % H_3PO_4, 0.2 % HNO_3 and 0.2 % H_2SO_4, respectively).
4- ES + P localized application (10 cm below soil surface), S as elemental sulfur, (150 g S/ pot) and P as mono calcium phosphate Ca $(H_2PO_4)_2$ 194 and 97 mg/pot for calcareous and non calcareous soil respectively.

Samples were collected at 8 weeks after sowing (3 replicate for each treatment). The growth parameters were recorded intern, plant height, number of leaves, shoot and root dry weight, and shoot to root ratio. Some macro-elements percentage in single cells of mesophyll tissues. Further more endogenous phytohormones in leaves were determined in third leaf from the top.

Determination of nutrient elements by EDX:

The distribution and composition of P, K, S and Ca in the leaf tissue were measured by energy-dispersive X-ray microanalysis (EDX) according to Koyro *et al* (1997).

Determination of Phytohormones

A five grams fresh weight from sunflower leaves was extracted in cold methanol 80%. The method of extraction was followed as described by Knget and Brunisma (1973). The method of endogenous hormones separation was followed as described by Lee *et al* (1989), GA_3, IAA and ABA were estimated by HPLC at Arid Land Agric. Research Unit Fac. of Agric., Ain Shams Univ.

Data of first and second experiments were statistically analyzed using SAS procedure (2004).

RESULTS AND DISCUSSION

First experiment

This experiment included eight treatments namely; control, monocalcium phosphate as foliar spray, chelated microelements as soil application, application of N, P and S as mineral acids, seed treatment with phosphorin, citric acid as foliar spray, humic acid and compost.

Growth

As shown in Table (4), it could be noticed that soil application of chelated microelements gave the maximum values of plant height (80.38 cm), and shoots dry weight (22.78 g/plant). Application of N, P and S as mineral acids, phosphorin, citric acid and humic acid positively affected plant height; but did not reach to the significant level. No significant effects were detected by the rest of treatments.

Table (4): Effect of different treatments on some vegetative growth characters of sunflower plants in the first experiment (10 weeks after sowing).

Treatment	Plant height (cm)	shoot dry wt /plant (g)	Root dry wt / plant (g)	Root : Shoot ratio
Cont.	66.56	15.80	3.01	0.19
Monocalcium phosphate (spray)	68.94	15.11	3.68	0.24
Microelements soil appl.	80.38	22.78	3.17	0.14
N,P, S Mineral acids	76.48	19.14	3.54	0.18
Phosphorin	75.38	13.91	3.90	0.28
Citric acid	77.38	12.85	3.98	0.31
Humic acid	76.63	14.50	3.99	0.28
Compost	61.75	14.78	3.82	0.26
LSD at 5%level	11.94	8.29	NS	

Nutrient elements

As shown in Table (5), soil application of microelements and application of N, P and S as mineral acids to sunflower plants significantly increased the concentration of P, K, Ca, Mg, Fe Zn and Mn. In fact, application of mineral acids gave the highest percentages of P in dry matter (0.31%), while the highest values of K (2.98%), Fe

(85 ppm) and Zn (30.2 ppm) were obtained by microelements soil application. Significant increase in Mn was attained by chelated microelements as soil application, whereas, most other treatments showed significant reduction on Mn content. Citric acid treatment increased P, Ca and Zn concentrations, whereas Compost treatment increased P, K and Zn.

Table (5): Effect of different treatments on some minerals concentration of sunflower plants (dry matter basic) in the first experiment (10 weeks after sowing).

Treatment	%				(ppm)		
	P	K	Ca	Mg	Fe	Zn	Mn
Cont.	0.22	2.33	2.67	0.23	79.5	20.9	21.2
Monocalcium phosphate (spray)	0.20	2.45	2.69	0.20	81.2	24.2	18.6
Microelements soil appl.	0.28	2.98	2.76	0.28	85.0	30.2	22.5
N,P, S Mineral acids	0.31	2.87	2.79	0.25	83.2	29.8	20.6
Phosphorin	0.25	2.38	2.70	0.23	82.9	25.3	19.9
Citric acid	0.28	2.45	2.73	0.20	81.4	28.1	19.3
Humic acid	0.26	2.55	2.71	0.23	79.5	26.9	18.7
Compost	0.27	2.56	2.66	0.24	78.3	27.5	19.8
LSD at 5%level	0.05	0.16	0.05	0.07	2.45	5.12	1.2

Application of microelements either as soil application or as foliar spray in combination with other materials such as citric acid provided the best treatments which improved sunflower plant growth. These effects were generally, accompanied by increasing in P, K, Fe, Zn and Mn concentrations in dry matter. These results are in agreement with those of Oonkasem and Thavarasook, 1991; El-Sersawy *et al*, 1996, Colapietra, 2000 and Mirzapour and Khoshgoftar, 2006, they mentioned the positive effect of microelements application on correcting microelements deficiency, improving uptake of nutrients, growth and yield of different plants.

It seems that compost had no positive effect under this experiment conditions. However, Sakal and Ali (1993) mentioned that, application of compost with $ZnSO_4$ markedly reduced the required amounts of $ZnSO_4$ to sugarcane plants grown on calcareous soil. Singh (1999) mentioned that, compost is needed to enhance the use of native and applied microelements. No doubt compost some advantage to calcareous soil, but sustainable amendments or fertilizers are needed. On the other hand, humic acid treatment enhanced plant height and shoots dry weight in sunflower, but failed to induce significant improvement. Olmos *et al* (1998) suggested that, humic products are useful in calcareous soil in improving the structure of the substrate, mobilizing of micronutrients toward the roots, also, act as biological hormones. Ayuso *et al*, 1992, indicated that humic acid improved the growth and yield of cereal plants grown on calcareous soils.

Second experiment

This experiment included four treatments namely; control, chelated microelements with irrigation water, mineral acids application and ES + P localized application.

Plant growth

Data presented in Table (6) indicate that all treatments significantly stimulated growth of sunflower either plants grown in non- calcareous or calcareous soils comparing with controls. Generally, all growth parameters were much higher in non- calcareous soil comparing with calcareous soil. Local application of ES+P gave the highest values of growth parameters followed by microelements and mineral acids treatments respectively.

However, ES+P treatment gave significant increase in plant height, number of leaves, shoot to root ratio and root dry weight. Whereas, shoot dry weight failed to reach the level of significance in calcareous soil.

It is obvious that placement application of ES+P enhanced plant growth due to the reduction of rhizosphere pH and reduction effect of the $CaCo_3$ by ES and increasing P and microelements availability. These results were in accordance with Awad *et al*, 1996, Kalocsai *et al* 2002, Abdel-Fattah *et al* 2005; Cimrin *et al* 2007 and Li Min *et al* 2007.

Table (6): Effect of different treatments on some growth characters of sunflower plants grown on both non- calcareous and calcareous soils (6 weeks after sowing).

Treatment	Plant ht. (cm)	No. of leaves /plant	shoot dry wt /plant (g)	Root dry wt /plant (g)	Root : Shoot ratio
			non- calcareous soil		
Cont.	35	7	13.4	3.60	0.27
N, S, P as Mineral acids	40	8	16.2	4.69	0.29
Microelements soil appl. (Chelated compounds)	39	8	15.5	4.32	0.28
E S +P (Local.Application)	54	10	18.3	5.32	0.29
LSD at 5%level	1.33	1.07	0.96	0.95	
			Calcareous soil		
Cont.	19	5	1.80	0.35	0.19
N, S, P as Mineral acids	22	6.5	2.00	0.50	0.25
Microelements soil appl. (Chelated compounds)	21	6.25	2.02	0.43	0.21
ES+P (Local.Application)	27	8.5	2.47	0.78	0.32
LSD at 5%level	2.03	0.90	NS	0.12	

Nutrient percentage in single cell of leaf

As mentioned previously, placement of the ES+P combination gave the most stimulation effect on sunflower plants growth. Hence, it was suggested to investigate the effect of this treatment on the concentration (%) of some macro elements namely, P, S, K and Ca in the photosynthetic tissue (mesophyll) of plants grown in both non-calcareous and calcareous soils comparing with their controls. Data in Fig. (1) clearly demonstrate that, localized application of ES+P recorded higher percentage of P and Ca and reduction in S and K elements in plant leaves in both non calcareous and calcareous soils comparing with their controls. Plants grown in non- calcareous soil showed high P and low Ca concentrations comparing with those in calcareous soil. The increase of P percentage in leaf tissue reflects the effect of ES+P placement treatment in increasing the availability of this element. Khater (1981) mentioned that sulfur application in calcareous soil was favorable for available P. Yosry *et al* (1984) found that DTPA- extractable Fe and Mn increased by elemental sulfur. Moreover, the placement of P with ES gives substantial additional increase in available P.

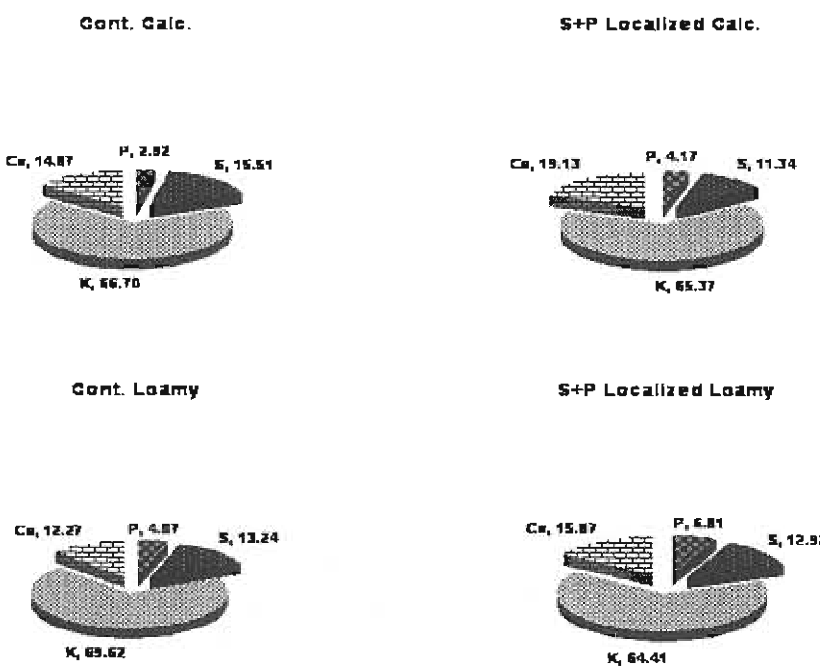

Fig. (1): Concentration of P, S, K and Ca elements (%) as measured by EDX in the leaf (mesophyll) tissues of sunflower plants grown on both non- calcareous and calcareous soils treated with localized ES + P.

Endogenous phytohormones:

The results obtained from the estimations of endogenous phytohormones (GA_3, IAA and ABA) in the 3[rd] leaf from the top of 8 weeks old sunflower plants treated with microelements, mineral acids and ES+P localized application are presented in Fig. (2).

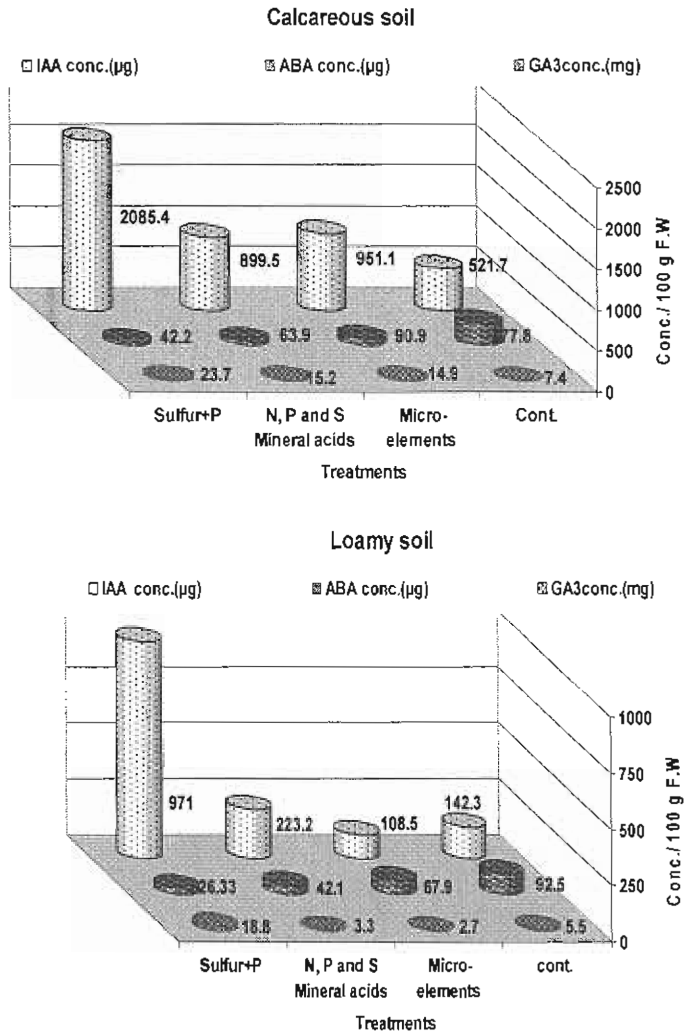

Fig. (2): Effect of different treatments on endogenous phytohormones conc. in sunflower plants grown on calcareous and non- calcareous soils.

These data showed that endogenous plant growth promoters (GA_3) was increased by ES+P treatment followed by mineral acids and micro elements respectively while IAA was increased by ES+P treatment followed by microelements and mineral acids respectively in calcareous soil. Whereas in non- calcareous soil, ES+P and mineral acid treatments increased IAA concentration while GA_3 was increased by ES+P treatment only. Plant grown in both non- calcareous and calcareous soils showed markedly reduction in (ABA) concentration by all treatments comparing with control plants. These results indicate that improvement of nutrient availability increased growth promoters (IAA and GA_3) biosynthesis. Hence, stimulate plants growth and development. The role of some elements in the biosynthesis of phytohormones such as the role of Zn with IAA is well documented by Daie *et al* (1979). The high level of the growth inhibitor ABA in plants grown in calcareous soil (control plants) was accompanied by reduction in plant growth and delay in development. The same result was obtained by Degenhardt *et al*, 2000.

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تحسين نمو نباتات عباد الشمس النامية تحت ظروف التربة الجيرية

محمد عبدالرسول[1]- إبراهيم الشامي[1]- أميرة حجازي[1]- أسامة خليل[1]
[1] قسم النبات الزراعي- كلية الزراعة- جامعة عين شمس- شبرا الخيمة- القاهرة- مصر

أجريت تجربتا أصص علي نبات عباد الشمس (صنف فيدوك) تحت ظروف التربة الجيرية تحت ظروف الصوبة خلال عامى 2001 و2003. و يهدف هذا البحث إلى تقييم إستجابة نبات عباد الشمس للمعاملات التى من شأنها تحسين الحالة الغذائية للنبات.
ويمكن تلخيص النتائج فيما يلى :

التجربة الأولي:

إضافة العناصر الصغرى المخلبية للتربة اعطت أعلى قيم لإرتفاع النبات والوزن الجاف للمجموع الهوائى. الزيادة السابقة كانت متزامنة مع الزيادة فى محتوى الفوسفور والبوتاسيوم والحديد والزنك والمنجنيز للأوراق.

إضافة الكبريت والنيتروجين والفوسفور فى صورة أحماض معدنية أعطت أيضاً زيادة فى النمو ومحتوى العناصر داخل النبات.

التجربة الثانية

الإضافة الموضعية للكبريت المعدنى وفوسفات الكالسيوم الأحادية سجلت أقصى قيم لبيانات النمو يتبعها المعاملة بالعناصر الصغرى ثم المعاملة بالأحماض المعدنية. كذلك سجلت الإضافة الموضعية للكبريت وفوسفات الكالسيوم الأحادية الزيادة فى نسبة الفوسفور والكالسيوم فى خلايا النسيج المتوسط بالورقة أيضا زيادة فى المحتوى الهرمونى للجبرلين وأندول حمض الخليك بينما حدث انخفاض ملحوظ فى حمض الأبسيسك.