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Soil Conditioning Potentials of a New Bio-Activator "Elixir" and Its Effect on Yield Increase of Cooled Plastic House and Pot Crops

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Abstract. Four experiments were conducted in Khartoum State in 2013 and 2014. The main objectives were to study the effect of a new bio-activator and organic fertilizer ''Elixir'' on growth and yield of cucumber, tomatoes, and Abu Sabien as well as testing the soil conditioning ability of the product. The two sites of cucumber and their combined results showed that application of Elixir (1.0 l/tunnel/week) in combination with NPK (1.0 kg 10:50:10 and 1.0 kg 10:10:35/tunnel/week), up to end of the crop, gave significantly high number of fruits/m^2 (123) and yield (10.53 kg/m^2) under cooled plastic house conditions compared to foliar fertilizer combined with NPK (high P and high K), Elixir alone and the control NPK (20:20:20) alone, all at the same rate. Results of Elixir applied as a soil conditioner at the rate of one liter per standard plastic house per week, up to end of the crop, on growth, productivity and quality of tomato, *Lycopersicon esculentum* Mill., fruits under cooled plastic houses was remarkably better compared to other soil conditioners, Humic acid, EM and Clean salt. Elixir application resulted in significantly high yields (145.5 t/ha) by tomato variety Newten. Significant reductions in the soil electrical conductivity (Ece.) were recorded by different application rates of Elixir: 5 ml, 10 ml, 15 ml, 20 ml and 25 ml, (2.7 to 2.9 dSm^{-1}) compared to the control (3.4 dSm^{-1}).

Keywords: Elixir, bio-fertilizer, soil conditioner, yield increase, cooled plastic house.

1 Introduction

In today's terminology organic farming is a method of farming system which primarily aims at cultivating the land and raising crops in such a way, as to keep the soil alive and in good health by use of organic wastes (crop, animal and farm wastes, aquatic wastes) and other biological materials along with beneficial microbes (biofertilizers) to release nutrients to crops for increased sustainable production in an eco-friendly pollution free environment [1]. In view of increasing global awareness, there are also growing research activities worldwide concerning organic inputs. The advantages of the organic system in terms of ecosystem conservation, food quality and economic performance have been demonstrated by numerous studies [2], [3] and [4]. In low-income countries of the tropics, NGOs and farmers' groups are now increasingly adopting organic techniques as a means of improving productivity and food quality and security. Total global land area under organic farming increased steadily from 11.0 million ha in 1999 to 35.3 million ha in 2008. These 35.3 million hectares of agricultural land are managed organically by almost 1.4 million producers. Countries with the largest organic land areas are Australia, Argentina and Brazil [5]. Area under organic farming in Sudan is only 54.8 thousand ha [6]. However, availability of organic inputs is an essential pre-requisite for expanding organic farming in Sudan.

In the last ten to fifteen years the importance of micro-organisms in decomposition of organic residues, release of nutrients, availing of nutrients to the pants in available forms and conditioning of soils were recognized and started to be utilized [7].The soil microbial biomass is a small but key component of the active soil organic matter pool and serves as a source and sink of soil nutrients [8]. From his plants

analysis, [9] reported that phosphorus concentration in plant parts increased with organic amendments.

Elixir is a new bio-activator and organic fertilizer produced in Sudan. All inputs of Elixir are organic and are readily available locally in Sudan. The product is proved eco-friendly and 100% safe for human beings, animals and plants and does not contain any harmful synthetic chemicals that cause allergy, toxicity or diseases. It contains considerable amounts of macro-elements and sufficient amounts of micro and trace elements and it also contains millions of beneficial micro-organisms which are living organisms produced from, and adapted to, tropical environments.

Heavy use of agrochemicals since the "green revolution" of the 1960s boosted food productivity at the cost of environment and society [10]. for the last three decades. Consequently, scientists looked back to nature and organic inputs gained more attention and support from the International Federation of Organic Agriculture Movements (IFOAM) and other environment concerned bodied all over the world. The main objectives of these experiments were to study the ability of Elixir to increase productivity and quality of cooled plastic house plant crops and to evaluate its soil conditioning potential.

2 Materials and Methods

Four experiments were carried out under cooled plastic house and pot experimentation conditions at different sites in 2013 and 2014 in Khartoum State (coordinates: 15:26 to 15:45N, 32:25 to 32:40E and 380 to 405m asl). The bio-activator and organic fertilizer "Elixir" was supplied by Bio-activator Factory for Agricultural Fertilizers, the Industrial Area, Khartoum North. Soil and plant analysis and the microbiological and chemical analysis of Elixir were carried out at the laboratories of the Department of Soil and Environment Science, Faculty of Agriculture, University of Khartoum. The main micro-organisms in Elixir are Photosynthetic Bacteria, Lactic Acid Bacteria, Yeast, Actinomycetes and Fungi. The pH is acidic and varied between 3.0 and 4.5. The main nutrients in Elixir are shown in (Table -1). Application means of Elixir were as shown in each experiment. The studied parameters were growth and yield parameters and they varied according to experiment. All collected data were summarized and statistically analyzed as shown for each experiment.

Table 1. The chemical analysis of elixir

ECe	N	P	K	Ca	Mg	S	Fe	Mn	Na	Cu
(dS/m^{-1})	(mg/l)	(ppm)								
6.0	3500.0	26.0	305.0	300.0	120.0	137.2	343.96	10.21	83.0	0.51

2.1 Effect of Elixir on Productivity and Fruit Quality of Cucumber

Two experiments were carried out in two cooled plastic houses to study the effect of Elixir combined with different nutrition packages on growth and productivity of cucumber *Cucumis sativus* L. variety Leader in the College of Agricultural Studies, Sudan University of Science and Technology in July 2014. The relative humidity and temperature were 80 to 85% and 25 to 31 ^{0}C, respectively, in tunnel I and 70 to 80% and 26 to 34 ^{0}C, respectively in tunnel II compared to about 40 ^{0}C outside the tunnel. The experimental design used was randomized complete block design with three replicates. One kg of NPK 20:20:20 was applied in each house as a basal dose after two weeks from sowing. The tested fertilizer combinations were applied in a weekly dose starting three weeks after sowing and continued up to end of the crop. Studied parameters were number of fruits per m^2 and yield (kg/ m^2) and the treatments were:

1.NPK 20:20:20. (1.0 g/plant).
2.{NPK 10:50:10, (1.0g) + 10:10:35, (1.0g) + Elixir (1.0ml)} per plant.
3.{NPK 10:50:10, (1.0g) + 10:10:35, (1.0g) + Elixir (0.5ml} per plant.
4.{NPK10:50:10, (1.0g) + 10:10:35 (1.0g) + Foliar fertilizer (Nuha) - (1.0g} per plant.
5.Elixir (1.0ml/plant).
6.Elixir (0.5ml/plant).

2.2 Effect of Elixir as a Soil Conditioner on Productivity and Fruit Quality of Tomato

This experiment was designed to study the effect of Elixir as a soil conditioner in comparison with three soil conditioners, namely, EM, Humic Acid and Clean Salt and the practiced chemical fertilizers as a control on growth, production and fruit quality of tomato *Lycopersicon esculentum* Mill. variety, Newten. The experiment was carried out in a cooled plastic house at Elshaer farm in West Omdurman during summer season (March to August) of 2013. The relative humidity and temperature were 80 to 85% and 25 to 32 ^{0}C, respectively, in the tunnel compared to about 42 ^{0}C outside the tunnel. Elixir was applied at the rate of one liter per standard single plastic house (9m X 36m) repeated on weekly bases starting two weeks after transplanting. The other soil conditioners and chemicals were applied as recommended or specified by the producers. The main measured parameters were plant height (cm), number of fruits/m^2, fruit diameter (mm), productivity (t/ha) and total soluble solids (TSS).

2.3 Effect of Elixir on Some Soil Properties and Plant Growth Parameters

A pot experiment was carried out at the Department of Soil and Environment Sciences, Faculty of Agriculture-University of Khartoum in 2014, to study the effect of different rates of application of Elixir, namely, 0.0, 5ml, 10ml, 15ml, 20ml and 25ml, added to soil with irrigation water, on soil conductivity (ECe) and plant growth e.g. plant fresh, dry weight and numbers of leaves. The area of the pot was 0.07m^2. Soil Ece (dSm^{-1}) and fresh, dry weights (g) and leaf number of the indicator plant (Abu Sabien) at the end of the experiment were measured.

3 Results and Discussion

3.1 Effect of Elixir on Productivity and Fruit Quality of Cucumber

The performance of Elixir in site I and II and their combined effect showed that cucumber treated with high and low concentrations of Elixir in combination with NPK (high P and high K) gave significantly high number of fruits/m^2 and yield/m^2 under cooled plastic house conditions compared to foliar fertilizer combined with NPK (high P and high K), both concentrations of Elixir alone and the control NPK (20:20:20) alone. Elixir as a bio-activator might have improved soil properties and availability of major elements. These results are in harmony with the finding of Yousif *et al.*, (2009) on effects of Amanda31. As well as, supporting increase in P amounts in plants under organic amendments was reported by Mejbah Uddin *et al.*, (2012). All other combinations gave almost similar results in both sites (Table2).

Table 2. Effect of elixir combined with different fertilizer combinations on number of fruits/m2 and yield (kg/m2) of cucumber under cooled plastic houses conditions in Khartoum State, 2014.

Parameter	No. of fruits/m^2			yield (kg/m^2)		
	Site I	Site II	Combined	Site I	Site II	Combined
NPK[1]	93.0	76.0	84.5	8.48	5.37	6.93
NPK[2]+H.Ex	128.0	118.0	123.0	11.51	9.54	10.53
NPK[2]+L.Ex	121.5	101.0	111.2	9.25	8.23	8.74
NPK[2]+FO	101.0	81.0	91.0	9.54	7.53	8.54
H. Ex	104.0	95.0	99.5	8.86	7.00	7.93
L. Ex	99.0	75.0	87.0	8.43	6.50	7.47
Grand mean	107.8	91.0	99.4	9.35	7.36	8.36
C.V %	7.7	9.2	8.14	8.9	15.9	13.0
SE(±)	6.97	6.83	6.87	0.68	0.96	0.9

NPK[1]: 20:20:20, NPK[2]: 10:50:10+ 10:10:35, H.Ex: High Elixir, L. Ex: Low Elixir

3.2 Effect of Elixir as a Soil Conditioner on Productivity and Fruit Quality of Tomato

Table (3) shows significantly high yields by Elixir (145.5t/ha), over yielding the other three soil

conditioners and the control. Elixir and Humic Acid performed equally and significantly better compared to EM, Clean Salt and control with regard to plant height. Furthermore, Elixir showed comparable results (113.5) to Humic Acid (108.2) and Clean Salt (103.5) as for number of fruits per meter square and they over numbered EM and control. Larger fruit diameters were reported by Elixir (69.77mm) and Humic Acid (68.85mm) and were significantly larger than for EM, Clean Salt and control. The highest TSS values were recorded by Elixir (5.10). The acidic nature of Elixir (pH 3.0 – 4.5) and the high number of micro-organisms in it might have improved the soil properties and changed the chemical compounds composition in the soil to readily available nutrients. Similar improvement in soil properties was reported by Yousif *et al.*, (2009). The overall performance of Elixir on growth, productivity and quality of tomato fruits under cooled plastic houses was remarkably better than the other soil conditioners known in Sudan.

Table 3. Effect of elixir and other soil conditioners on plant height, number and diameter of fruits, yield and TSS of tomato grown in cooled plastic houses in West of Omdurman, 2013.

Parameter	Plant height (cm)	Number of fruits per (m^2)	Fruit diameter (mm)	Yield (t/ha)	TSS
Elixir	282.9	113.0	69.77	145.5	5.10
EM	267.5	101.5	64.15	120.5	4.50
Humic Acid	285.4	108.2	68.85	131.5	4.97
Clean salt	260.1	103.5	61.10	112.2	4.18
Control	231.2	102.2	57.65	95.5	3.58
SE±	3.71	4.74	2.28	6.26	0.24
CV%	2.00	6.30	5.00	7.30	7.80

3.3 Effect of Elixir on Some Soil Properties and Plant Growth Parameters

The results on table (4) show significant ($p = 0.037$) reduction in the soil electrical conductivity by different application rates of Elixir (2.9, 2.7, 2.9, 2.8 and 2.8 dSm^{-1} for 5ml, 10ml, 15ml, 20ml and 25ml, respectively, compared to the control (3.4 dSm^{-1}). However, the differences between the application rates of Elixir were not statistically significant. In agreement with [9], the application of Elixir had significantly ($P = 0.001$) affected the produced fresh weight, dry weight and number of leaves. Likewise, there were no significant differences between different application rates. Application of Elixir improved soil Ece as well as fresh and dry weights and leaf number of the indicator plant, Abu Sabien. Elixir being acidic and the high numbers of micro-organisms in it might have reduced the soil pH and improved the availablility of nutrients. Supporting increase in P amounts in plants under organic amendments was reported by Mejbah Uddin *et al.*, (2012).

Table 4. Effect of elixir on soil Ece. (at the end) and the plant growth parameters of Abu Sabien, in a pot experiment, at Shambat, 2014.

Parameter	Soil Ece. (at the end) (dSm^{-1})	Fresh wt. (g)	Dray wt. (g)	Leaf No.
0 ml	3.2	8.9	7.3	6.3
5 ml	2.9	10.0	8.6	8.7
10 ml	2.7	9.6	8.0	8.7
15 ml	2.9	9.5	7.6	8.5
20 ml	2.8	9.2	8.9	7.5
25 ml	2.8	9.5	8.8	8.5
Grand mean	2.9	9.4	8.2	8.0
Prop.	0.037	<.001	<.001	<.001
SE(±)	0.13	0.28	0.32	0.40
CV%	5.8	1.6	2.1	6.2

4 Conclusions

1.The bio-activator, Elixir, improved soil physical and chemical properties.
2.Application of Elixir at the rate of one liter per week per standard single plastic house (9m X 36m) coupled with NPK (1.0 kg 10:50:10 and 1.0kg 10:10:35/tunnel/week), up to end of the crop, for cucumber and tomato crops under cooled plastic house growing conditions resulted in significant increase in yields.

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