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Evaluation Of Soil Conditioner (Barbary-Plant (BP) Fertilizer) On Cucumber Hybrids (Cucumis Sativus L.) Under Cooled Plastic Houses Conditions In Khartoum State

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Abstract – This experiment was conducted for two successive seasons (June to September 2016 and January to mid April 2017) in cooled plastic house at Shambat Research Station, Agricultural Research Corporation, Sudan. The objective of this study is to investigate the effect of Barbary - plant (BP) fertilizer; third generation (G3) on growth, yield and quality of two cucumber hybrids. The experiment was laid out in a split plot design with four fertilizer treatments namely; 50g Barbary-Plant (BP) fertilizer, 75 g (BP), 100 g (BP) and (NPK) fertilizer as a check in rate 1.0 - 12.5g / plant during season, used as a sub plot, and two hybrids (A and B) as main plot replicated three times. The means were compared using Duncan Multiple Range Test (DMRT) at P $\leq$ = 0.05. Seventy five g of (BP) per plant resulted in a significant increase in plant height, number of flowers and fruits per plant, total fruit yield (kg/m^2), number of fruits/m^2, fruit height and fruit diameter followed by 50 g (BP), NPK and 100g (BP). Moreover, using of 75 g (BP) resulted in a significant saving of water irrigation followed by 50 g (BP) and 100 g (BP). Likewise, using of (BP) reflecting in controlling of pests and diseases and extended the harvesting period of the crop. Based on the statistical and economical analysis, the study recommended the application of the soil conditioner Barbary-plant (BP) at the rate of 75g per plant of cucumber (60kg (BP)/300m$^{2)}$ in Sudan.

Keywords – Cucumber *(Cucumis sativus* L.), Greenhouse, Soil conditioner (BP), Growth, Yield, Quality

I. INTRODUCTION

Cucumber is one of the oldest cultivated vegetables probably native to India and is an important vegetable crop in U.S.A; where it is produced in a large scale. (Salunkhe and Desai, 1984). Cucumber (*Cucumis sativus* L.) is one of the most popular members of the cucurbitaceae (vine crop) family. *Cucumis'* are the main genera cultivated in the tropics for their edible fruits (Njoroge, 2001).

The cucumber is a very popular crop for greenhouses production (Hochmuth, 2005). Management of cucumber production is very complicated and requires specialized knowledge (Yun et al., 2001). It is generally consumed fresh or pickled. The pickling cultivars produce smaller fruits but all cultivars may be used for both purposes (Splittstoesser, 1984), it is a primary source of vitamins and minerals in the human diet, but the caloric and nutritional value of cucumber is very low (Choudhury, 1976).

Greenhouse cucumbers grow quickly (Elamin, 2007) and are heavy nutritional feeders, weekly feedings with a balanced fertilizer are required for maximum production; therefore, they should never being subjected to water or nitrogen stresses (Hunter, 1998).

Recent developments in intensive agriculture and high uses of fertilizers contributed immensely towards foods. Eventually this trend is expected to leave undesirable residues in food products. Today there is an increasing in awareness throughout the world towards the uses of fertilizers in sustainable agricultural practices couples with the avoidance of their harmful effects.

Barbary-Plant (BP) is a soil conditioner consisting of a sodium acrylamide acrilate copolymer with macro - and micronutrients, fungicide and root growth promoter and other components that improve nutrient availability, water retention and aggregate stability in the soil manufactured by a French company (Román-Paoli and Sotomayor-Ramírez, 2004). The product (BP) is a polymer that contains 6.5 % N, 4.8% P and 8.2% K carried on 42% hydro polymer (Román-Paoli and Sotomayor-Ramírez, 2004). The Barbary plant composition is shown in appendix (1).

The manufacturer states that nutrient availability, water retention and aggregate stability were improved by application of BP to the soil and holds around 500 times its weight of water. Román-Paoli and Sotomayor-Ramírez (2004) reported that when Barbary plant (BP) is mixed with soil it would slowly release water and nutrients as the plant roots penetrate the product particles, it increases soil water holding capacity, decreases irrigation frequency and hence the cost of irrigation. (Jamnicka et al., 2013 and Tongo et al., 2014). Moreover, he claimed that nutrients and water remain in the soil particle if not absorbed by roots, then increasing water holding capacity and reducing potential leaching. Barbary fertilizer is known to be positively affecting the vegetative growth in term of plant height, number of flowers and fruits per plant and it eventually enhance crop productivity and quality (Román-Paoli and Sotomayor-Ramírez, 2004).

Barbary-Plant has been evaluated in several areas of the world and showed good results. It was tested in Hyderabad, India for corn and sunflower production (Rao, 1997). BP has been tested also in China, Egypt (Farid et al., 1996), Emirate (UAE) (APG, 2007), Lebanon (SARL, 1966) and the Republic of Nigeria (NAFDC, 2014) and commented as useful to improve physical and chemical properties of heavy clay soils like Vertisol.

Advanced cucumber cultivation must supply the crop with optimal rates of nutrients throughout the growth cycle in the most efficient manner possible, and without degrading soil and water resources. The nutrient uptake rate by greenhouse cucumbers is very high (Dickerson, 1996).

Production of cucumber in greenhouses is facing serious challenges. Selection of the most suitable hybrids is a prerequisite for a successful cucumber culture in Sudan. Unfortunately, there are many cucumber hybrids were used under green house but no specific cucumber hybrid is selected and officially released.

The objective of this study is to investigate the efficacy of different levels (50g, 75g and 100g per plant) of the Barbary plant BP (soil conditioner) and NPK fertilizer on cucumber production under greenhouse condition.

II. MATERIALS AND METHODS

Experimental design

The experiment was carried out at the first week of June to September 2016 (first season) and from January to mid April 2017 (second season). The experiment was laid out in a split plot design with three replicates. The treatments were combination of two cucumber hybrids (A and B) and four fertilizer rates namely; 50g Barbary-Plant (BP) fertilizer, 75 g (BP), 100 g (BP) and (NPK) fertilizer 1.0 - 12.5g/plant during season. Experimental unit (plot size) was 70cm (width) X4m (length).

Soil

Shambat soil is clay loamy type with high content of clay predominantly montemorillonite, slightly alkaline with pH range between 7.5 - 7.7. The soil analysis before and after this experiment was illustrated in appendix (2).

Green house environment

Shambat (Lat. 15^{o} 40′ N, Long. 23^{o} 32′E and at of 380 meters above sea level). The green house condition is that it was well conditions covered with bolyethelyene sheet (200 micron). The temperature inside about 25^{o}C – 30^{o}C and relative humidity about 63 – 77%

Source of materials

Two cucumber hybrids (denoted as A and B) were selected from different hybrids evaluated by (ARC) Sudan,

Husbandry

Sowing was done on both sides of the seed bed. The bed was 70 cm in width and spacing between plants was 40 cm. The application of Barbary plant was done once manually on seedlings of 12 days after sowing. The NPK fertilizer was added manually twice weekly starting two weeks from the time of planting the seeds. Irrigation was done using drip system every day for 15 – 20 minutes, reduced to 10 minutes for the area treated with Barbary plant (PB).Weeding was done weekly when recommended. Diseases and insects were controlled chemically when needed. Pruning operation for the side branches and yellow leaves is usually done.

Harvesting

Crop harvest for the first pick was made about 32 days after planting. The harvesting season continued for almost 3 months. Picking interval is 2 - 3 days for 2 months and then every 4 - 5 days interval for the last month.

Data collection

Data collection and statistical analysis were exercised for vegetative parameters, yield and quality parameters. Plant height, number of flowers and fruits/plant were measured and recorded every week. Number of days to 50 % flowering, average yield of cucumber (kg /m^2) and its direct components (number of fruits/m^2, average weight of fruit (g), fruit length (cm), fruit diameter (cm) were recorded, other quality parameters such as fruit shape and colour were observed also.

Statistical analysis:

Data were subjected to analysis of variance for the split plot design, and means were separated using Duncan's Multiple Ranges Tests (DMRT) at $P \leq 5$ % level, and for yield per unit area combined analysis for the two seasons were performed. The statistical package GenStat edition 12^{th} was used to run the analysis.

III. Results and discussion

The influence of Barbary Plant on plant height is presented in Table (1). The significantly high plant height was recorded (for the two cucumber hybrids across the two seasons) by the rate of 75 grams of the product per plant followed by 50 g BP, NPK, and 100 g of BP respectively; with no significant differences between the other treatments. This finding in agreement with Farid et al., (1996) who stated that Barbary conditioner increase cucumber plant height.

Influence of Barbary plant on the days to 50% flowering presenting in (Table 1); in both seasons. The Barbary plant at dose of (75g) resulted in significantly earlier flowering with an average of (24) days compared to NPK fertilizer after (28) days in average.

Table (2) showed the effect of Barbary-plant (BP) on number of flowers and fruit set per plant for the two cucumber hybrids in the two seasons. It is quite evident that the dose of 75 g of (BP) per plant outnumbered the other treatments. For both flowers per plant and fruit set per plant, 75 g dose of Barbary conditioner was significantly highest; followed by 50 g, NPK and 100 g Barbary respectively in the two seasons. This in agreement with (Farid et al., 1996 and Panayiotis et al., 2004) who postulated that Barbary conditioner increase number of flowers and fruits per plant compare to untreated cucumber in different seasons. These results certainly reflex the ability of hydro gel BP to provide plants with their nutrients up take, water and micronutrients needs beneficially. Hybrid A yielded greater number of flowers and fruits per plant compare to the other with significant differences, and season one yielded the best; number of flowers and number of fruits; than the other with significant differences.

The average weight of fruit, average fruit length and diameter are presented in table (3). Fruit weight is considered the most important components for the ultimate yield of the crop followed by diameter and length. The dose of 75g of Barbary-Plant (BP) fertilizer per plant scored significantly values of fruit weight, fruit diameter and fruit length than the others. This indicates that the optimum dose of (BP) fertilizer of 75grams per plant, positively affect the fruit diameter, fruit length and hence fruit weight. On the other hand, both hybrids were characterized by smooth shape and has a nice attractive colour ranged from green to light green.

Table (4) showed the effect of (BP) soil conditioner on fruits yield (kg/m^2) and fruit number/m^2 of two cucumber hybrids during two seasons. Fruit weight (kg/m^2) of cucumber and fruit number per square meter was highest in 75g Barbary followed 50g, NPK and 100g Barbary consequently in the two hybrids and the two seasons, with a significant difference between all treatments.

Combined mean of fruit weight of 75g dose for BP outscored (34.7kg/m^2) over (BP 50g dose was 21.8kg/m^2), (NPK was 20.3kg/m^2) and (BP 100g was 18.4kg/m^2) respectively. Similar results were obtained for the combined mean of number of fruits per/m^2, where 75 g Barbary significantly scored (258) compared to (BP 50g dose 177 fruits/m^2), (NPK 162 fruits /m^2) and (BP 100g 155fruits/m^2).

The obtained results have shown that the soil conditioner (BP) is strongly and positively affects the normal vegetative and reproductive development of the plant leading to a far better yield and quality. Similar results of (BP) were obtained in other crops such as wheat, mandarin and olive as reported by (Hamdy and Sfeir, 2002., Pattanaaik et al., 2015 and Chehab et al., 2017). Also, in agreement with (Farid et al., 1996 and Pattanaaik et al., 2015) who found that Barbary conditioner increase number of fruits and fruit yield. As cucumbers are known to be heavy nutritional feeders and water lovers and in order to obtain maximum yields of the crop, Weekly feedings with a balanced fertilizer and continuous supply of irrigation water will be required (Hochmuth, 2005).

Table (5) showed the pooled analysis for the crop yield (weight kg/m^2 and fruit number /m^2) to show the interaction between the treatments. Fruit weight was significantly affected by the interaction of the fertilizer doses and seasons. Likewise, fruit number was significantly affected by the interaction of cucumber hybrids and fertilizer doses. In contrast, there were no significant differences between both Hybrid with Season (two interactions) and Hybrid, fertilizer with Season (three interactions).

Economic Analysis

Gross marginal and partial budget analysis for different rates of application was presented in tables 6, 7 and 8. Dominance and marginal analysis were used to show the most economically viable treatments. The marginal rate of return (MRR) estimated the return to investment. The marginal rate of return is equal to the marginal net benefit divided by the marginal cost times hundred. The highest marginal rate of return (11975.5%) was obtained from using 75gm BP/plant (60kg BP/greenhouse).

IV. Conclusions:

Application of Barbary- Plant (BP) affect all characters studied positively (plant growth, yield and its components and fruits quality).Using (BP) reduced water and fertilizers requirements of the crop, and the duration of the daily irrigation frequency was reduced from (20 minutes/day) to (10 minutes/day). It reduced standard fertilizers application from (three times a week) to (two times a week) which reflected in reducing the cost of production.

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TABLES

Table (1): Effect of (BP) soil conditioner on plant height and days to 50% flowering of two cucumber hybrids during two seasons

Hybrid	**Plant height/plant(cm)**			**Days to50% flowering**		
	Seasons					
	2016	**2017**	**Mean**	**2016**	**2017**	**Mean**
A	246.3[a]	219.3[a]	232.8	26[a]	27[a]	27
B	240.0[a]	218.6[a]	229.3	26[a]	27[a]	27
SE±	4.09	3.13		1.32	1.67	
Fertilizer	**Seasons**					
	2016	**2017**	**Mean**	**2016**	**2017**	**Mean**
50 g/ plant	245.0[b]	224.1[b]	234.6	25[ab]	26[b]	26
75 g/ plant	292.9[a]	239.3[a]	266.1	24[a]	24[a]	24
100g/ plant	228.0[c]	207.7[c]	217.9	29[c]	30[c]	30
NPK(1-12.5) g/plant	236.7[b]	205.4[c]	221.1	27[b]	29[c]	28
SE±	3.57	2.95		1.59	1.83	
CV%	4.39	4.23		3.87	3.40	

Means followed by the same letter(s) are not significantly different at P≤ 0.05 according to Duncan's multiple Range Test (DMRT

Table (2): Effect of (BP) soil conditioner on number of flowers and fruit set/plant of two cucumber hybrids during two seasons

Hybrid	Number of flowers/ plant			Number of fruit set/ plant		
	Seasons					
	2016	2017	Mean	2016	2017	Mean
A	38[a]	33[a]	36	34[a]	29[a]	32
B	30[a]	31[a]	31	29[a]	27[a]	28
SE±	3.05	1.11		1.72	0.99	
Fertilizer	Seasons					
	2016	2017	Mean	2016	2017	Mean
50 g/ plant	38[b]	32[b]	35	35[b]	27[b]	31
75 g/ plant	49[a]	40[a]	45	41[a]	35[a]	38
100g/ plant	27[c]	28[c]	28	23[c]	24[c]	24
NPK(1-12.5) g/ plant	28[c]	31[b]	30	25[c]	25[c]	25
SE±	2.49	1.76		2.03	1.58	
CV%	9.16	6.34		8.17	6.21	

Means followed by the same letter(s) are not significantly different at P≤ 0.05 according to Duncan's multiple Range Test (DMRT

Table (3): Effect of (BP) soil conditioner on average fruit weight (g), fruit diameter (cm) and fruit length (cm) of two cucumber hybrids during two seasons

Hybrid	Fruits weight(g)			Fruit diameter (cm)			Fruits length(cm)		
	Seasons								
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
A	128.9[a]	124.5[a]	126.7	4.5[a]	3.8[a]	4.2	20.1[a]	17.8[a]	18.9
B	127.3[a]	123.2[a]	125.3	4.6[a]	3.8[a]	4.2	19.6[a]	17.5[a]	18.6
SE±	2.56	1.24		1.06	0.09		0.39	0.18	
Fertilizer	Seasons								
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
50 g/ plant	130.0[b]	122.7[b]	126.4	4.4[b]	3.8[b]	4.1	21.1[b]	17.7[b]	19.4
75 g/ plant	136.5[a]	132.5[a]	134.5	6.3[a]	4.7[a]	5.5	23.2[a]	19.3[a]	21.3
100g/ plant	118.5[c]	118.2[b]	118.4	3.7[c]	3.3[bc]	3.5	17.3[c]	16.4[c]	16.9

NPK(1 - 12.5)g/plant	127.5[b]	121.9[b]	124.7	3.8[c]	3.6[bc]	3.7	17.8[c]	17.3[b]	17.6
SE±	2.80	2.67		0.14	0.19		0.18	0.27	
CV%	2.90	2.51		6.20	4.60		4.10	3.40	

Means followed by the same letter(s) are not significantly different at P≤ 0.05 according to Duncan's multiple Range Test (DMRT)

Table (4): Effect of (BP) soil conditioner on fruits yield (kg/m^2) and fruit number/m^2 of two cucumber hybrids during two seasons

Hybrid	**Fruit weight kg/m^2**			**Number of fruits/m^2**		
	Seasons					
	2016	**2017**	**Mean**	**2016**	**2017**	**Mean**
A	24.4[a]	22.4[a]	23.4	189[a]	180[a]	185
B	25.0[a]	23.4[a]	24.2	194[a]	187[a]	191
SE±	1.10	0.77		10.70	9.61	
Fertilizer	**Seasons**					
	2016	**2017**	**Mean**	**2016**	**2017**	**Mean**
50 g/ plant	22.7[b]	20.8[b]	21.8	184[b]	169[b]	177
75 g/ plant	35.3[a]	34.0[a]	34.7	263[a]	253[a]	258
100g/ plant	18.9[c]	17.9[c]	18.4	154[d]	155[c]	155
NPK(1-12.5)g/plant	21.5[bc]	19.0[bc]	20.3	165[c]	159[c]	162
SE±	1.41	1.21		14.70	15.21	
CV%	3.90	7.33		7.42	7.04	

Means followed by the same letter(s) are not significantly different at P≤ 0.05 according to Duncan's multiple Range Test (DMRT)

Table (5): Mean squares of the combined analysis of variance for fruit yield (Kg /m^2) and fruit number /m^2 of two cucumbers and four fertilizes evaluated during two seasons.

Character	**Hybrid (d.f = 1)**	**Fertilizer (d.f =3)**	**Hybrid* Season (d.f = 1)**	**Fertilizer* Season (d.f = 3)**	**Hybrid* Fertilizer (d.f = 3)**	**Hyb.*Fer.* Season (d.f = 3)**	**Pooled error (d.f=36)**
Fruit weight/m^2	7.704*	571.650**	0.337	19.760**	7.705	0.405	4.374
Fruit number/m^2	1363.3	24581.9**	32.3	494.9	1585.8**	363.9	438.0
*	**Significant at P ≤ 0.05**						
**	**Significant at P ≤ 0.01**						

Data were analyzed together to examine the treatments * season interaction effect

Economic analysis:

Table 6: Partial budget analysis on the effect of BP soil conditioner on fruit yield (kg/m²) of cucumber under cooled plastic house (300m²) conditions

Treatment	Yield kg/m²	Yield kg/300m²	Cucumber price SDG/kg	Gross return SDG/300m²	Variable cost SDG/300m²	Gross margin SDG/300m²
200 g (Bp) /m² (40kg (BP) /300m²)	21.2	6360	7	44520	516.6	44003.4
300g (BP) /m² (60kg(BP) / 300m²)	34.0	10200	7	71400	739.2	70660.8
400g (B-P) /m² (80 kg (BP) /300m²)	18.2	5460	7	38220	961.8	37258.2
NPK / 300m²	20.8	6240	7	43680	3850.0	39830.0

Price of 1kg BP = $ 0.7, US $ exchange rate: $1= SDG 15.9

Price of 1kg BP =SDG 11.13

Average cost of NPK fertilizer added in greenhouse = 3850 SDG/300m²

Cost of adding soil conditioner in greenhouse (labour cost) =71.4 SDG/300m²

Price of 1kg cucumber = 7 SDG/kg

Table 7: Marginal and dominance analysis on the effect of BP soil conditioner on fruit yield (kg/300m²) of cucumber under cooled plastic house conditions

Treatment	Yield kg/300m²	Cucumber price SDG/kg	Gross return SDG/300m²	Variable cost SDG/300m²	Gross margin SDG/300m²	Dominance
200 g (Bp)/m² (40kg (BP)/300m²)	6360	7	44520	516.6	44003.4	
300g (BP)/m² (60kg(BP)/ 300m²)	10200	7	71400	739.2	70660.8	
400g (B-P)/m² (80kg(BP)/300m²)	5460	7	38220	961.8	37258.2	D
NPK/300m²	6240	7	43680	3850	39830	D

Table 8: Gross marginal analysis and marginal rate of return

Treatment	Yield kg/300m^2	Gross margin SDG/300 m^2	Variable cost SDG/300 m^2	MR SDG/300 m^2	MC SDG/300m^2	MRR%
200 g (Bp)/m^2 (40kg (BP)/300m^2)	6360	44003.4	516.6	0	0	
300g (BP)/m^2 (60kg(BP)/ 300m^2)	10200	70660.8	739.2	26657.4	222.6	11975.5

Appendices:

Appendix I: Barbary-Plant (BP) composition reported by manufactures.

Item	Components
Macronutrients	%
N- P_2O_5 – K_2O	18 -18 – 18
Micronutrients	
B	200
Cu	60
Fe	480
Zn	160
Mn	600
Mo	60
Fungicides	%
Hymexazol	20
Potassium Hydroxide	45
Growth Regulators	
Alfa naftilacetamide	0.018
Alfa-naftalenacetic acid	0.002
Thio – Urea	0.098

Appendix 2: Soil analysis before planting:

Depth (cm)	$CaCo_3$%	Mechanical analysis			Exchangeable Bases			O.C.	N	C/N
		Sand	Silt	Clay	Na	K	CEC			
0 - 30	5.6	31	42	27	1.6	0.3	26	0.390	0.037	11
30 – 60	5.7	32	42	26	1.5	0.6	27	0.468	0.038	12

Depth	Ava. P (ppm)	pH	EC ds/m	Soluble cation and anions					Bulk density		Available moistur capacity (%)	
				Na	Ca	Mg	cl	HCo_3	Dry	wet	Wt.	Vol.
0 - 30	4.3	8.0	0.8	6.7	1.3	0.4	2.3	3.0	1.11	1.90	20.7	23.2
30 – 60	4.3	7.8	0.9	6.5	1.7	0.6	2.3	3.5	1.07	1.87	18.9	20.0

Appendix 2 (continue): Soil analysis after first harvest: (first season)

Depth (cm)	$CaCo_3$%	Mechanical analysis			Exchangeable Bases			O.C.	N	C/N
		Sand	Silt	Clay	Na	K	CEC			
0 - 30	4.0	32	40	28	1.75	0.70	25	0.390	0.039	11
30 – 60	4.3	30	43	27	1.60	1.00	26	0.468	0.038	12

Depth	Ava. P (ppm)	pH	EC ds/m	Soluble cation and anions					Bulk density		Available moisture capacity (%)	
				Na	Ca	Mg	Cl	HCo_3	Dry	wet	Wt.	Vol.
0 - 30	4.3	8.1	1.0	6.7	1.3	0.5	2.5	3.1	1.90	1.12	20.7	23.2
30 – 60	4.1	7.8	1.1	6.5	2.1	0.5	2.7	3.4	1.85	1.09	18.4	20.0

Appendix 2 (continue): Soil analysis after second harvest: (second season)

Depth (cm)	$CaCo_3$	Mechanical analysis			Exchangeable Bases			O.C.	N	C/N
		Sand	Silt	Clay	Na	K	CEC			
0 - 30	5.92	33	40	27	1.6	0.847	26	0.02	0.084	-
30 – 60	4.85	34	38	28	1.5	0.471	27	0.11	0.083	-

Depth	Ava. P (ppm)	pH	EC ds/m	Soluble cation and anions					Bulk density		Available moisture capacity (%)	
				Na	Ca	Mg	cl	HCO_3	dry	Wet	Wt.	Vol.
0 - 30	2.4.	8.1	0.558	1.6	6.5	1.5	-	3.1	-	0.0	14.7	20.58
30 – 60	1.6	8.1	0.502	1.5	1.7	7.5	-	3.4	-	2.25	20.94	29.32

Source Soba Research Station (ARC), Sudan