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IMPACT OF TRICKLE IRRIGATION AND BIOFERTILLIZATION ON SOIL RESPIRATION, MICROBIAL ACTIVITY AND WATER USE EFFICIENCY OF QUINUA UNDER WATER STRESS

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Key Wards: Air permeability, CO_2 evolution, bio-fertilizer, water use efficiency (WUE).

ABSTRACT

A field study was conducted in the winter season of 2017 at the Agricultural Experimental Station of Wadi Suder, south Sinai (D.R.C.), to evaluate the effect of soil organic matter, trickle irrigation depth and bio-fertilizer (*Azotobacter chroococcum, Bcillus megatherium and Bacillus circulans*) on soil properties such as air permeability, total porosity, carbon dioxide evolution and microbial activity on quinoa yield and water use efficiency (WUE) of quinoa yield (*Chenopodium quinoa*willd). Water use efficiency (WUE) was calculated as a result of cumulative improvement of studied parameters. The results revealed that soil air permeability increased by 49.9% with increasing the organic matter. Trickle irrigation depth reduced the permeability by 7.2 % when depth reached 10cm and 44.6% at 20cm depth. For bio-fertilizers, soil permeability increased by 48, 47 and 52% as general medium increase for (*Azotobacter chroococcum, Bcillus megatherium* and *Bacillus circulans* respectively, these increases achieved when organic matter increased by 100% at zero, 10 and 20cm of trickle irrigation depth. Whilst, *Bcillus megatherium* as a sole treatment surpassed other bio fertilizers. Meantime, air permeability increased by 112% as a result of increasing porosity by 9% this mean that every 1% of porosity improvement led to increasing respiration 12%. Also, soil respiration improved by increasing carbon dioxide evolution whatever, increasing respiration by 112% refer to increasing CO_2 evolution by 84% (every 1% CO_2 increase led to increased respiration by 1.33%) Total porosity decreased by trickle depth by 2.7%, while comparing to control it increase at each depth, this increase reached 9.6, 8.03 and 6.79% for depths zero, 10 and 20cm respectively. Biofertilizers also increase soil porosity by 7.6, 9.2 and 8.08% for *A.chroococcum, B.megatherium* and *B.circulans* comparing to control. Also, total porosity increased by increasing additive organic manure from 0.5 to 1% by 5.1%. Quinoa seed and straw yields promoted by 22 and 21% as organic matter increase for seed and straw yields respectively. Meantime, irrigation depth and biofertilizers haven't direct significant effect however, they hve an important role though indirect effect on soil permeability, total porosity and soil respiration. Also, permeability increasing by 112% enhanced seed and straw yields by 82% (725kg/fed.) and 92 %(884kg/fed.), for seed and straw yields respectively. This means that every 1% improvement in permeability led to increase in seed and straw by 6.5kg/fed., and 8kg/fed., respectively. Water use efficiency for seed and straw affected significantly by organic matter. In contrast, irrigation depth, and carbon dioxide have a non significant correlation with the two yield parameters, while air permeability show the values (r= 0.505*, r= 0.435NS), for water use of seed and straw, respectively. Carbon dioxide and permeability when coupled with organic matter as mixing technique show significance correlation value with water used of seed and straw. CO_2 increased with different biofertilization treatments, maximum value obtained with phosphate dissolving bacteria (*B.megatherium*), depth of latellier and organic matter 10 T/fed being 13.1 mg CO_2/100g dry soil/24 hr with 85% of increase over control.

INTRODUCTION

Calcareous soil problems defined as rising of pH value, active calcium carbonates occurrence and weak physic- mechanical properties like porosity, air permeability and thermal parameters **(Baver et al., 1976).** In addition, physical problems, such as formation of surface crusts which affects directly on roots and soil respiration consequently increase soil co_2 and may be affecting on water use efficiency **Russell, (1989). Daniel et al. (2003)** evaluated the emission of soil CO_2, N_2O, CH_4 and soil carbon and N indicators for four years after manure and compost application, and They found that the emission of CO_2 were similar between control and other treatments, also, fluxes of CH_4- C and N_2O-N were nearly zero. **Hiroko and Haruo (2003)** application of poultry manure (PM), swine manure (SM) and chemical fertilizers (urea) into soil, as well as interaction between organic matter and tillage stimulated NO_2 emission. **Akinremi et al. (1999)** studied the effect of soil temperature and moisture on soil respiration with barley and fallow. Wherever it ranged from a low of 1.6 g CO_2 $m^{-2}d^{-1}$ on dry day to a high of 8.3 g CO_2 $m^{-2}d^{-1}$ on a wet day for fallow while the corresponding values for barely where 3.3 and 18.5 CO_2 $m^{-2}d^{-1}$, respectively. Also, **Sandra et al. (2003)** found that hydrocarbon emissions briefly were enhanced in wet soil than in dry soil.

Daniel et al. (2000) investigated the effect of alfalfa roots and shoots mulching on soil physical characters as total porosity and he found an increase in total and macro porosities by 1.7 and 1.8, respectively. Also, **El-Hadidi et al. (2002)** investigated the addition of gypsum, farmyard manure and sand on soil physical properties and found that, bulk density was decreased at all treatments but porosity was increased for farmyard manure and bio-solids application alone or as mixing technique, **Khalifa and El-Eissawy (2002)** mentioned that sandy soil tilled with previous treatments has the lowest bulk density and the highest porosity. **Wagieh (2002)** found that soil porosity and pore size distribution were improved as soil moisture depletion decreased from 70 to 50%, this may be ascribed to the effect of moisture depletion on the number of wetting and drying cycle.

Application of Plant Growth Promoting Rhizobacteria (PGPR) inoculants is a promising measure to combat salinity in agricultural fields, thereby increasing global food production. **Ilangumaran, and Smith (2017).**

Inoculation of crop plants with beneficial microbes is gaining agronomic importance since they facilitate cultivation under saline-prone conditions by improving salt tolerance and hence, restoring yield **Lugtenberg et al. (2013).**

Irrigation scheduling is one of the factors that influence the agronomic and economic viability of small farmer. It is important for both water savings and improved crop yields. The type of soil and climatic conditions have a significant effect on the main practical aspects of irrigation, which are the determination of how much water should be applied and when it should be applied to a given crop. Other important elements should also be considered, such as crop tolerance and sensitivity to water deficit at various growth stages, and optimum water use. Water shortage is a serious problem affecting plant growth and yield in the Mediterranean region **Souza et al., (2004)**.

Improving food crop production in the arid and semiarid regions. Influenced by multiple abiotic stresses, by strengthening a diversified crop production and introducing new climate-proof crops and cultivars with improved stress tolerance such as quinoa (chenopodium quinoa willd). Deficit irrigation strategy (DI) has been widely investigated as a valuable and sustainable production strategy in dry regions. By limiting water applications to drought sensitive growth stages, this practice aims to maximize water productivity and to stabilize, rather than maximize, yields **Geerts and Raes, (2009)**. Benefits of deficit irrigation derive from three factors: increased irrigation efficiency, reduced costs of irrigation and the opportunity costs of water **English and Raja, (1996)**. Quinoa comes from the Andean highlands of South America, It has a high nutritional value of protein, vitamins and minerals **Jensen et al.,(2000)**, and it is drought and frost resistant crop **García,et al., (2007); Jacobsen et al.,(2009)**, and salt **Jacobsen et al,(2009).**

The main target of this study is to improve calcareous soils respiration and microbial activity and water use efficiency of quinoa and to achieve the best production for quinoa crop,all of them through adding compost levels, various trickle irrigation depths and bio-fertilizers**.**

MATERIALS AND METHODS

The field experiment was carried out at the Agricultural Experimental Station of Wadi Suder, south Sinai (D.R.C.), in winter season of 2017/2018 ranged in split-split plot design, the main plot was represented by two levels of composted farmyard manure application rates, i.e. 0.5 and 1 %. Sub plots were three depths of irrigation water 0.0, 10 and 20 cm and Sub Sub plots were three bio-fertilizers {*Azotobacter chroococcum (1), Bacillus megatherium (2)* and *Bacillus circulans (3)*}with three replicates for each treatment. Thus, the experimental plots were: (2 rates for farmyard manure) x 3(irrigation water depths x 3typs of bio-fertilizers x 3(replicates) =54 plots. After soil preparation, plots were divided into (5 lines/ plot) and sown by quinoa after seeds infuse in water for about twenty four hours, at (14 pits / line) at 15 th November 2017.

Soil physical analysis:

Soil porosity and s**oil air permeability** were calculated according to **Richards (1954).**

Bacterial culture preparation: Fresh liquid cultures 48 hrs old from pure local strains of *Azotobacter chroococcum, Bacillus megatherium* and *Bacillus circulans*previously isolated from the rhizosphere soils of South Sinai, purified and identified according to **Bergey's Manual (1994)** as biofertilizers at the rate of ~10^8cfu/ml.

Microbial determinations

Soil samples of Quinoarhizosphere were collected at the end of both seasons and analyzed for total counts of microorganisms according to **Nautiyal et al., (2000**) usingthe decimal plate method technique. Bacillus counts according to Pikovskoys agar medium PVK **Goenadi et al., (2000).** CO_2 evolution according to **Anderson (1982)**

Soil Enzymatic activity:

Soil samples were analyzed for: Dehydrogenase activity according to method described by **Casida *et al.*, (1964)**.Phosphatase activity was measured using as enzyme substrate as described by **Őhlinger (1996).**

Water consumptive use:

Soil moisture content determined at 3 depths; 0-20, 20-40 and 40-60 cm. The actual evapotranspiration (ETa) for each stage as well as for the total season were determined, crop coefficient was calculated for every growth stage according to **Allen *et al*, (1989),** Crop Water Use

Efficiency (WUE), kg/m^3 was calculated by dividing the crop yield by the amount of seasonal evapotranspiration **Giriappa, (1983). NPK** mixture fertilizer was added once as activate portion at tillering stage by the rat of 50 kg/fed. The initial physical and chemical properties of Wadi Suder soil, farmyard manure and irrigation water shown in table (1).

Table (1): physical and chemical properties of initial soil, organic manure and irrigation water.

<table>
<tr><th rowspan="3">Physical properties</th><th colspan="9">Particle size distribution</th><th colspan="4" rowspan="2">soil thermal conductivity cal/cm/s/ºc</th><th colspan="2" rowspan="2">Bulk density</th></tr>
<tr><th colspan="2">Sand</th><th colspan="2">Silt</th><th colspan="2">Clay</th><th colspan="3">Texture class</th></tr>
<tr><td colspan="2">85</td><td colspan="2">7.02</td><td colspan="2">7.98</td><td colspan="3">L.S</td><td colspan="4">9.5</td><td colspan="2">1.53</td></tr>
<tr><th rowspan="2">Chemical properties</th><th colspan="2">$CaCO_{3\%}$</th><th colspan="2">ECdS/m</th><th colspan="2">pH</th><th colspan="3">CEC meq/100g soil</th><th colspan="6">OM%</th></tr>
<tr><td colspan="2">51.9</td><td colspan="2">10.4</td><td colspan="2">7.9</td><td colspan="3">2.8</td><td colspan="6">0.25</td></tr>
<tr><th rowspan="2">Farmyard manure</th><th colspan="2">C%</th><th colspan="2">N%</th><th colspan="2">C:N</th><th colspan="3">P ppm</th><th colspan="4">K ppm</th><th colspan="2">OM%</th></tr>
<tr><td colspan="2">23.5</td><td colspan="2">1.9</td><td colspan="2">12:1</td><td colspan="3">17.5</td><td colspan="4">125</td><td colspan="2">40.42</td></tr>
<tr><th rowspan="3">Irrigation water</th><th colspan="11">Soluble cations and anion meq/l</th><th rowspan="2">SAR</th><th colspan="2" rowspan="2">ECdS/m</th><th rowspan="2">pH</th></tr>
<tr><th>Na</th><th>Ca</th><th>Mg</th><th colspan="2">K</th><th colspan="2">Cl</th><th>CO_3</th><th colspan="2">HCO_3</th><th>SO_4</th></tr>
<tr><td>45.6</td><td>24.9</td><td>4.9</td><td colspan="2">0.44</td><td colspan="2">55.8</td><td>-</td><td colspan="2">1.9</td><td>19.03</td><td>9.6</td><td colspan="2">7.24</td><td>7.55</td></tr>
</table>

RESULTS AND DISCUSSION

Impact of studied treatments on soil air permeability:

One of the main soil respiration entrances is soil air permeability which affected by organic matter, irrigation depth and bio- fertilizers. In general, table (2) shows that soil air permeability increase by 49.9% as organic matter increase. Trickle irrigation depth led to decreasing permeability by 7.2 % when depth reached 10cm and 44.6% at 20cm depth. For biofertilizers, soil permeability increased by 48, 47 and 52% for *A.chroococcum*, *B.megatherium* and *B.circulans* respectively, these increases achieved when organic increased by 100% at zero, 10 and 20 cm of trickle irrigation depth. While *B.megatherium* as sole treatment surpassed other biofertilizers. Fig (1) declares that organic matter has a significant effect on permeability whereas, a non significant relation found with trickle irrigation depth.

But, these treatment when mixed together give a strong correlation with permeability, generally the simple and multiple correlations values were 0.859***, -0.494 NS, 0.158 NS and R= 0.981*** for organic matter, trickle irrigation, bio-fertilizer and interaction, respectively, and the multiple regression was $Y= 3.7E\text{-}05+7.07E\text{-}06x_1- 1.08E\text{-}06x_2+3.3E\text{-}06x_3$, where Y, x_1,x_2 and x_3 are air permeability, organic matter, trickle irrigation depth and bio-fertilizer, respectively.

Table (2). Some soil physiochemical properties and quinoa yield as affected by studied factors.

Depth of latellier/cm	Organic Manure Ton/fed.	Bio fertilization	CO$_2$/100g dry soil	Air permeability	Total porosity	Seed yield kg/fed	Straw yield kg/fed
0 cm	5	*A.chroococcum*	8.3	7.51 E-05	35.04	932.92	958.9
		B.megatherium	9.2	7.80E05	36.10	1020.2	1292
		B.circulans	8.8	7.60E05	35.30	987.2	1170
	10	*A.chroococcum*	11.3	11.41 E-05	37.19	1015.2	1172
		B.megatherium	13.1	11.90E-05	37.80	1190.8	1640
		B.circulans	12.9	11.50E-05	37.32	1072.9	1290
10 cm	5	*A.chroococcum*	7.6	6.70E-05	34.80	1079.9	1280
		B.megatherium	8.4	7.53E-05	35.06	1215	1360
		B.circulans	8.1	7.45E-05	35.04	1209	1296
	10	*A.chroococcum*	9.9	10.30E-05	36.60	1478.3	1568.4
		B.megatherium	11.1	10.80E-05	36.90	1602.8	1842.9
		B.circulans	10.8	10.77E-05	36.80	1573.0	1792.8
20 cm	5	*A.chroococcum*	7.1	5.60E-05	34.60	877.6	1390.8
		B.megatherium	7.6	6.50E-05	34.70	1032.7	1382
		B.circulans	7.2	5.63E-05	34.62	982.6	1203.6
	10	*A.chroococcum*	9.2	7.90E-05	36.19	1197.6	1511.8
		B.megatherium	9.8	9.60E-05	36.40	1211.8	1503.9
		B.circulans	9.5	9.20E-05	36.22	1029.6	1380

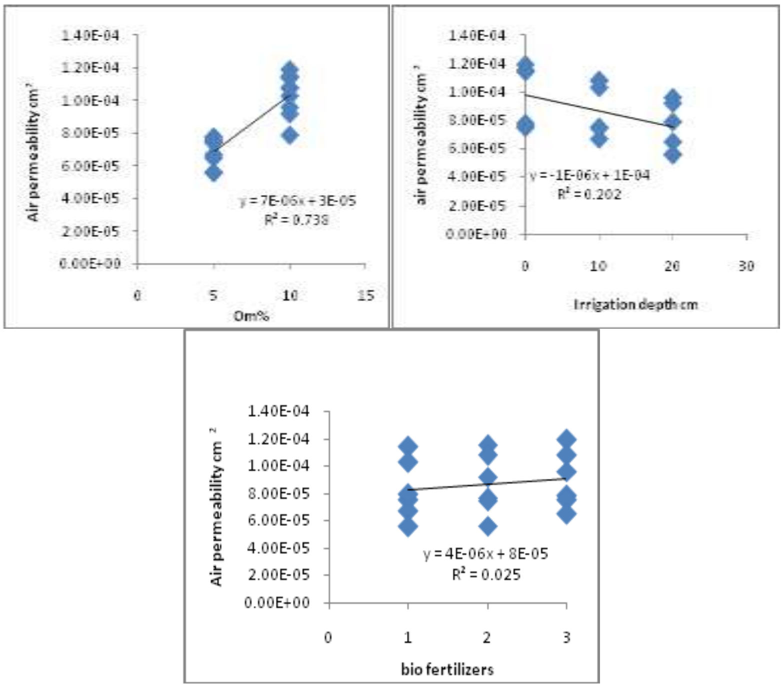

Fig (1). Air permeability affected by studied factors.

Impact of studied treatments on soil porosity:

A second way to express soil respiration is soil porosity which shown in table (2),it increased by increasing additive organic manure from 0.5 to 1% by 5.1%, whereas, porosity increase by addition organic manure comparing to initial soil by 8.73 and 13.8% for 0.5% and 1% respectively. Soil porosity also decreased by depth by 2.7% while comparing to control it increase at each depth, this increase reached 9.6, 8.03 and 6.79% for depths zero, 10 and 20cm respectively. Bio fertilizers also increase soil porosity by 7.6, 9.2 and 8.08% for *A.chroococcum*, *B.megatherium* and *B.circulans* comparing to control. Fig (2) declare the simple regression relations of studied factors and the positive significant between organic matter and soil porosity while, each of trickle depth and bio-fertilizers has no significant relation with soil porosity, the simple correlation emphasize this relation where were as follow 0.883 ***, -0.402NS and 0.167NS for organic matter, trickle depth and bio- fertilizers respectively. By mixing all study factors it gives a highly significant multiple correlations where R=0.960*** and the multiple regression was $Y= 33.3+ 0.36 x_1 – 0.04x_2 + 0.18x_3$ where Y, x_1, x_2 and $x_3$are porosity, organic matter, trickle depth and bio-fertilizer respectively.

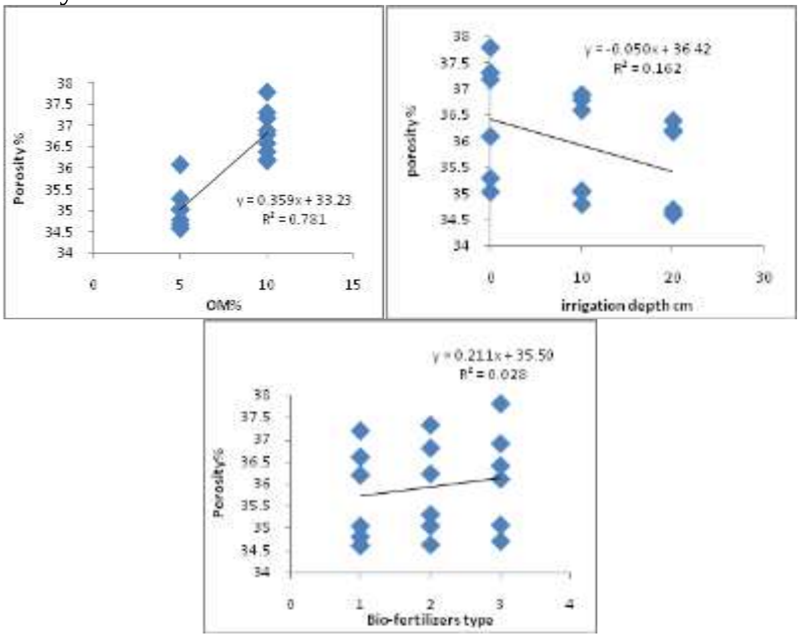

Fig (2). Soil porosity affected by studied factors.

Air permeability relating to porosity and carbon dioxide:

Soil respiration happen as a result of porosity improvement and carbon dioxide evolution. Tables (2) point out that soil respiration increased by 112% as a result of increasing porosity by 9% this mean that every 1% of porosity improvement led to increasing respiration 12%. Also, soil respiration improved by increasing carbon dioxide evolution whatever, increasing respiration by 112% refer to increasing CO_2 evolution by 84% (every 1% CO_2 increase led to increased respiration by 1.33%). Fig (3) come to assure this result which declare the linear relation among respiration, porosity and CO_2 and the simple correlation values were r= 0.963*** and 0.959*** for porosity and CO_2evolution with respiration respectively.

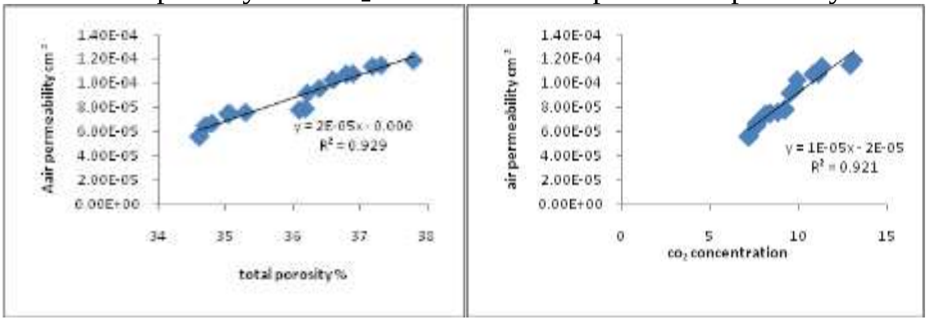

Fig (3). Soil air permeability relating to soil porosity and CO_2evolution.

Soil microbial activities in rhizosphere of Quinoa plant affected by studied factors:

To examine the effect of biofertilization treatments on microbial and soil enzymatic activities in rhizosphere of quinoa, soil CO_2 evolution and enzymes dehydogenase and phosphotase were determine and explain as follow:

CO_2 evolution:

CO_2 was determined as an indicator of the biological activity in quinoa plant rhizosphere. Initial CO_2 in quinoa rhizosphere was 7.1mg CO_2/100g dry soil/24 hrthis value increased with different biofertilization treatments, maximum value obtained with phosphate dissolving bacteria (*B.megatherium*), depth of latellier and organic matter 10 T/fed being 13.1 mg CO_2/100g dry soil/24 hr with 85% of increase over control. These results in compatible with those described by **Visser and Dennis, (1992).**

Table (3) show the values of soil enzymes Dehydrogenase and Phosphatase which were measured to study the effect of different biofertilization treatments, depth of latellier and organic matter on soil enzymatic activity at harvesting stage of quinoa, soil enzymes varied within different biofertilization treatments and quinoa genotypes. *B.megatherium* inoculation gave higher values for soil enzymatic activity than *B.circulans* and *A.chroococcum*

Table (3). CO_2 evolution and enzymatic activity in quinoa rhizosphere affected by studied factors.

Depth of latellier	Organic manure ton/fed	Bio	CO_2 evolution (mg CO_2/100g dry soil/24 hr)	Dehydrogenase (µlDHA/g dry soil)	Phosphatase
0 cm	5	Control	7.1	11.6	0.12
		A.chroococcum	8.3	12.9	0.14
		B.megatherium	9.2	13.5	0.16
		B.circulans	8.8	13.2	0.15
	10	Control	7.6	12.3	0.12
		A.chroococcum	11.3	13.9	0.15
		B.megatherium	13.1	14.3	0.19
		B.circulans	12.9	14.1	0.18
10cm	5	Control	6.8	11.3	0.12
		A.chroococcum	7.6	12.6	0.13
		B.megatherium	8.4	13.1	0.14
		B.circulans	8.1	12.9	0.14
	10	Control	7.3	11.8	0.12
		A.chroococcum	9.9	13.1	0.15
		B.megatherium	11.1	13.8	0.17
		B.circulans	10.8	13.5	0.15
20cm	5	Control	6.2	10.9	0.11
		A.chroococcum	7.1	11.8	0.12
		B.megatherium	7.6	12.1	0.13
		B.circulans	7.2	12	0.12
	10	Control	7	11.3	0.11
		A.chroococcum	9.2	12.8	0.14
		B.megatherium	9.8	13	0.15
		B.circulans	9.5	12.9	0.14
L.S.D. at 5%			0.064	0.082	0.05

Total microbial counts: initial total microbial counts before cultivation were 51 ×10^5 cfu/g dry soil

Table (4) show that Total microbial counts differ with different biofertilization treatments which might be due to the simulative effect of added biofertilizers on microbial community in quinoa plant rhizosphere and leads to increase total microbial counts. The enhancement of microbial activity is a good indicator for many soil improvements.

The highest counts were associated with (*A.chroococcum, Bacillus megatherium and Bacillus circulans)* being 96,112 and 108 ×10^5cfu/g dry soil respectively. These results are in consonance with those obtained by **Ashrafuzzaman et al., (2009)** who reported that, inoculation with the plant growth promoting rhizobacteria, had stimulation effect on the population of rhizosphere microorganism and increased their numbers by more than 50% at the end of the experiment comparing with the number recorded before planting.

Bacillus counts: The initial counts of Bacillus in Wadisurdr soil was 25 ×10^2cfu/ gm dry soil. Data recorded in Table (4) showed a marked increase in counts. The counts under (*Bacillus megatherium)* showed the highest counts.

Table 4. Total microbial counts and PDB counts in quinoa rhizosphere affected by studied factors.

Depth of latellier	Organic matter ton/fed	Bio fertilizzers	Total microbial counts $\times 10^5$cfu/g dry soil	PDB counts $\times 10^2$cfu/g dry soil
0 cm	0	Control	51	25
		A.chroococcum	68	36
		B.megatherium	75	42
		B.circulans	71	40
	10	Control	70	30
		A.chroococcum	96	41
		B.megatherium	112	49
		B.circulans	108	47
10cm	0	Control	47	24
		A.chroococcum	60	33
		B.megatherium	72	39
		B.circulans	68	36
	10	Control	66	27
		A.chroococcum	77	35
		B.megatherium	93	44
		B.circulans	86	41
20cm	0	Control	39	23
		A.chroococcum	51	29
		B.megatherium	63	34
		B.circulans	57	32
	10	Control	58	25
		A.chroococcum	73	31
		B.megatherium	84	40
		B.circulans	77	37
L.S.D. at 5%			1.62	1.09

Quinoa seed and straw yields affected by soil permeability, CO_2 and studied factors:

Quinoa yield comes as proceeds of organic matter, applied water, bio-fertilizers treatment and improved soil respiration whatever, Table (2) point out that, seed and straw yields increased by 22 and 21% as organic matter increased respectively. Meantime, irrigation depth and biofertilizers have no direct significant effect however, they have an important role though indirect effect on soil permeability, total porosity and soil respiration. Also, permeability increased by 112% resulted in an increase on seed and straw yields by 82% (725kg/fed.) and 92 %(884kg/fed.), for seed and straw yields respectively. This means that every 1% improvement in permeability led to increase in seed and straw by 6.5kg/fed., and 8kg/fed., respectively. Therefore, Fig (4) show these significant and non significant effects on quinoa yield, and simple and multiple correlations were: (r=0.104NS, r=0.264NS), (r=0.236NS, r=0.365NS), (r=0.415NS, r=0.435NS), (r= 0.542*, r=0.484NS), (r=0.550*, r=0.605*), and (R= 0.664*, R= 0.624*) for seed and straw yields with irrigation depth, bio fertilizer, CO_2 evolution, air permeability, organic matter and interaction. The multiple regressions were: $Y_1=1016+16x_1+16059434x_2-146x_3$ and $Y_2= 1080+61.8x_1-41649x_2-15.8x_3$, where Y_1,Y_2,x_1,x_2,x_3 are seed, straw, organic matter, air permeability and CO_2 evolutions, respectively.

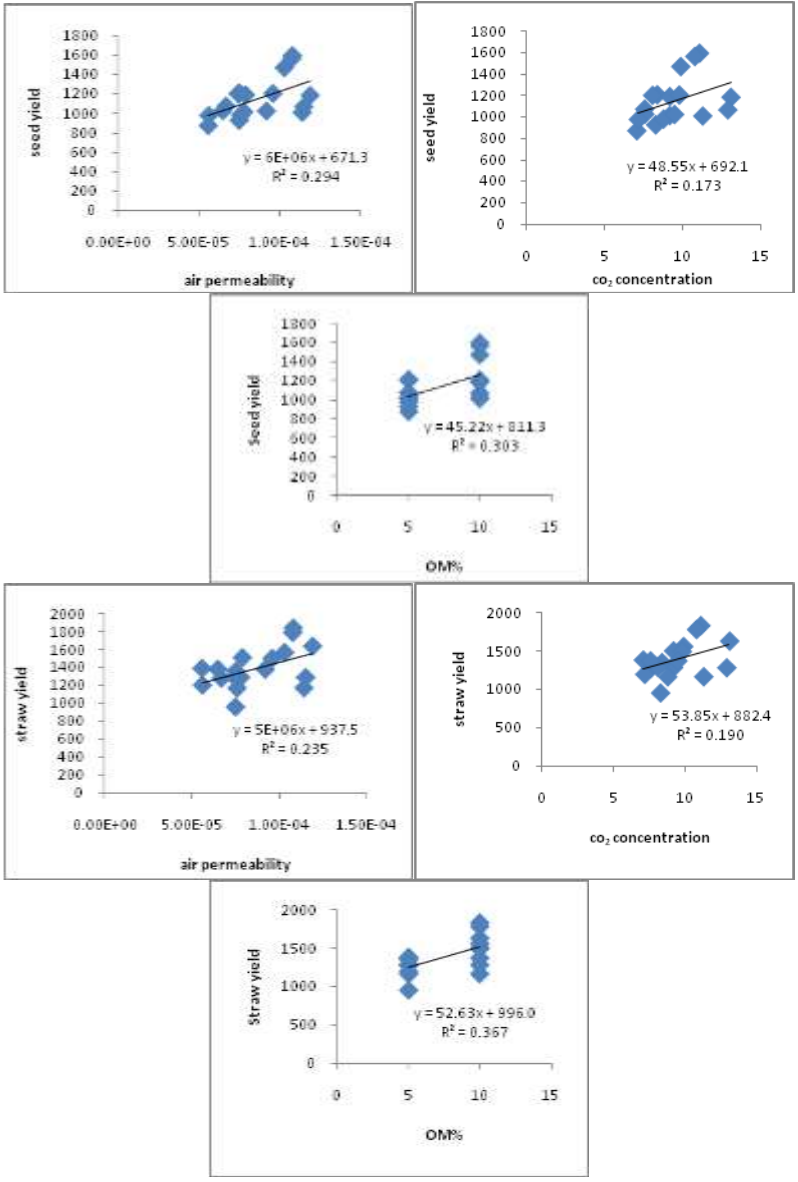

Fig: (4) seed and straw yield affected by air permeability, CO_2evolution and organic matter.

Water use efficiency:

Improving water use efficiency requires a development of satisfactory means to estimate crop water requirements or evapotranspiration (ETo). Water use efficiency as cumulative study involves Eta and yield that called Water economy which express the water quantity by cubic meter need to product one kilo gram of quinoa seed and straw yield. This ratio is to coming out improved all the previous studied parameters and treatments. Whatever, table (5) and Figs (5, 6) illustrate that seed and straw water use efficiency affected significantly by organic matter r=0.554* and r=0.589* respectively. in contrast, irrigation depth, bio- fertilizers and carbon dioxide show no significant correlation with the two yield parameters where, , (r=0.126NS, r= 0.356NS) and (0.232NS, 0.346NS), (r=0.375NS, r=0.379NS) while air permeability show the values (r= 0.505* , r= 0.435NS), for water use of seed and straw, respectively. Carbon dioxide and permeability when coupled with organic matter as mixing technique show significance correlation value were: R= 0.672* and R= 0.670* for water used of seed and straw respectively, and the multiple regression were: $Y_1=0.851+0.021x_1+1100.7x_2-0.116x_3$ and $Y_2=0.89+0.05x_1-689.7x_2-0.02x_3$ where, Y_1, Y_2,x_1,x_2 and x_3 are water use of (seed, straw), organic matter, permeability and carbon dioxide, respectively.

Table (5): Applied water and water use efficiency for seed and straw yields.

treatments			Actual Evapotranspiration of different stages(mm)				Total Eta (mm)	Total Eta (m3)	WUE straw	WUE seed
lateral depth	Organic manure Ton/fed	biofertilizer	In.	Devil.	Mid	late				
0.0cm	5 ton/fed	*A.chroococcum*	25.32	62.98	154.79	73.98	317.07	1331.694	0.72006	0.700551
		B.megatherium	24.96	62.42	153.92	73.52	314.82	1322.244	0.977127	0.771567
		B.circulans	25.01	62.07	153.6	73.54	314.22	1319.724	0.886549	0.748035
	10 ton/fed	*A.chroococcum*	24.27	61.67	153.63	72.74	312.31	1311.702	0.893496	0.773956
		B.megatherium	24.18	61.18	153.5	72.37	311.23	1307.166	1.254623	0.910978
		B.circulans	24.23	61.21	153.44	72.24	311.12	1306.704	0.987217	0.821073
10cm	5 ton/fed	*A.chroococcum*	23.48	60.37	152.46	71.49	307.8	1292.76	0.99013	0.835345
		B.megatherium	23.05	59.11	152.17	71.08	305.41	1282.722	1.060245	0.947204
		B.circulans	22.61	59.43	151.94	71.00	304.98	1280.916	1.011776	0.943856
	10 ton/fed	*A.chroococcum*	22.26	59.23	151.86	70.9	304.25	1277.85	1.227374	1.156865
		B.megatherium	21.98	59.18	150.94	70.81	302.91	1272.222	1.448568	1.259843
		B.circulans	22.12	59.21	151.03	70.74	303.1	1273.02	1.408305	1.235644
20cm	5 ton/fed	*A.chroococcum*	21.93	59.11	150.96	70.13	302.13	1268.946	1.096028	0.691598
		B.megatherium	21.23	58.63	150.56	68.81	299.23	1256.766	1.099648	0.821712
		B.circulans	21.43	58.57	150.61	69.12	299.73	1258.866	0.956099	0.780544
	10 ton/fed	*A.chroococcum*	21.86	57.37	150.62	69.67	299.52	1257.984	1.201764	0.951999
		B.megatherium	21.40	57.21	150.38	69.28	298.27	1252.734	1.200494	0.967324a
		B.circulans	21.36	57.20	150.40	69.17	298.13	1252.146	1.102108	0.822268
CONTROL			25.62	64.02	156.34	74.79	320.77	1347.234	0.549125	0.527228

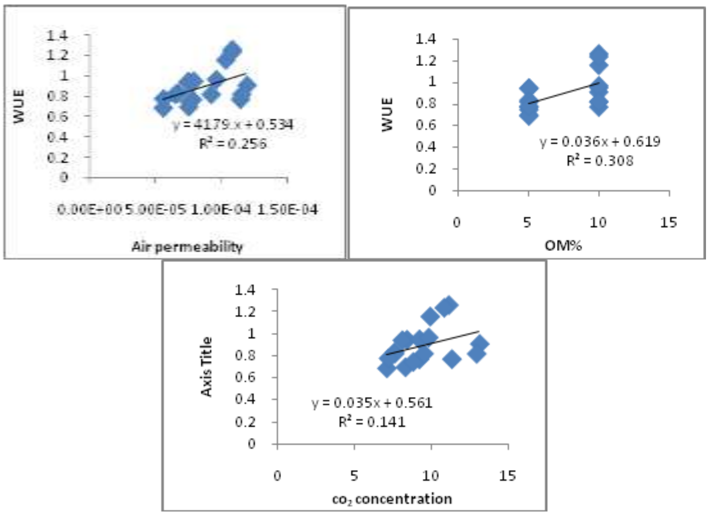

Fig (5) WUE of seed affected by air permeability, Co$_2$concentration and organic matter.

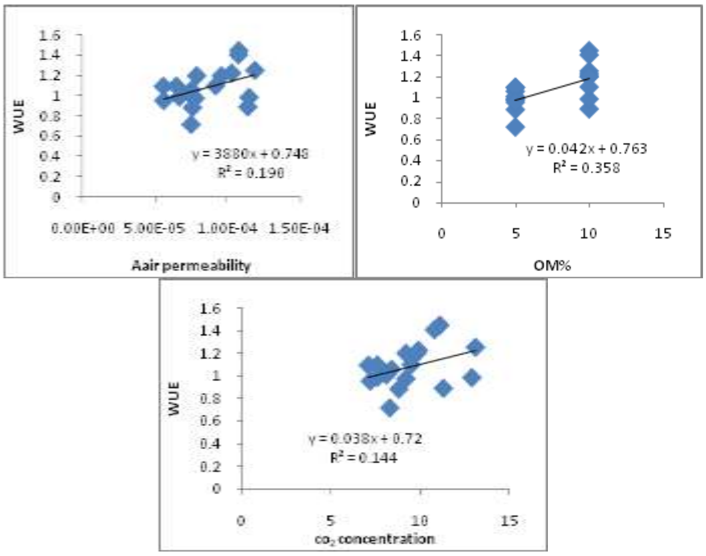

Fig (6)WUE of straw affected by air permeability, Co$_2$concentration and organic matter.

CONCLUSION

Based upon results, the following can be concluded:

The effects of the applied treatments which improve most of studied soil characters terminally affect positively the crop yield parameters. This complementally effect sustained over the studied successive season of cultivation with quinoa crop which indicate durability of these treatments in face of environmental and climatological conditions.

The obvious role of organic matter and soil respiration in producing crops has been detected with yield parameters while, irrigation depth and bio fertilizers role hasn't detect, in which organic manure application had the major role in improving quinoa crop, WUE based upon it has the magnitude values of correlation. Whilst, organic matter, respiration and carbon dioxide led to increase seed and straw yields and WUE by mixing technique through significantly effect on the all aforementioned studied parameters.

Soil air permeability increase by 49.9% as organic matter increase. Trickle irrigation depth led to decreasing permeability by 7.2 % when depth reached 10cm and 44.6% at 20cm depth. For bio-fertilizers, soil permeability increased by 48, 47 and 52% as general medium increase for *A.chroococcum, Bacillus megatherium and Bacillus circulans*respectively, these increases achieved when organic matter increased by 100% at zero, 10 and 20cm of trickle irrigation depth. *Bacillus megatherium* as a sole treatment surpassed other biofertilization treatments. Meantime, air permeability increased by 112% as a result of increasing porosity by 9% this mean that every 1% of porosity improvement led to increasing respiration 12%. Also, soil respiration improved by increasing carbon dioxide evolution whatever, increasing respiration by 112% refer to increasing CO_2 evolution by 84% (every 1% CO_2 increase led to increased respiration by 1.33%). Total porosity decreased by trickle depth by 2.7%, while comparing to control it increase at each depth, this increase reached 9.6, 8.03 and 6.79% for depths zero, 10 and 20cm respectively. Bio fertilizers also increase soil porosity by 7.6, 9.2 and 8.08% for *A.chroococcum, Bacillus megatherium and Bacillus circulans*comparing to control. Also, total porosity increased by increasing additive organic manure from 0.5 to 1% by 5.1%. We recommended with using these biofertilization treatments as mixture which will maximizes its benfits .

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تاثير الرى تحت سطحى والتسميد الحيوى على تنفس التربة والنشاط الميكروبى وكفاءة الاستهلاك المائى للكينوا تحت ظروف الاجهاد المائى

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1- قسم خصوبة وميكروبيولوجيا الا راضى – مركز بحوث الصحراء

2,3 – قسم كمياء وطبيعة الراضى – مركز بحوث الصحراء

اقيمت تجربة حقلية للموسم الشتوى 2017- 2018 بالمحطة الاقليمية لمركز بحوث الصحراء بمنطقة وادى سدر – جنوب سيناء لدراسة تاثير كل من المادة العضوية وعمق خط الرى (تنقيط تحت سطحى) والتسميد الحيوى على بعض خواص التربة الطبيعية (نفاذية الهواء – المسامية الكلية – تراكم غاز ثانى اكسيد الكربون) و تنفس التربة والنشاط الميكروبى وانعكاس ذلك على الانتاجية وكفاءة الاستهلاك المائى لمحصول الكينوا وقد اشارت النتائج الى

– زيادة نفاذية التربة للهواء بنسبة 49.9% بزيادة المادة العضوية. عند عمق 10سم خط التتقبط ادى الى نقص النفاذنة بنسبة 7.2 و44.6 عند عمق 20 سم .

– فى حين زادت النفاذية مع التسميد الحيوى بنسبة 48.7% و52% كمتوسط عام لكل من البكتريا المثبتة للفوسفات والبوتاسيوم على التوالى وكان للبكتريا المثبتة للفوسفات دور واضح عن باقى اللقاحات .

– حدثت زيادة فى النفاذية بنسبة 112% كنتيجة لذيادة المسامية بنسبة 9% وهذا يعنى انه عند تحسن المسامية المسامية بنسبة 1% يؤدى الى تحسن تنفس التربة بنسبة 12%. وقد ادت زيادة تصاعد غاز ثانى اكسيد الكربون بنسبة 1% الى تحسن فى تنفس التربة بنسبة

1.33%.وعموما نقصت المسامية الكلية بنسبة 2.7% مقارنة بالكنترول فى حين ادى التسميد الحيوبالى ذيادة المسامية بنسبة 7.6، 9.2، 8.08 لكل من البكتريا المثبتة للازوت والبكتريا الميسره للفوسفات والبوتاسيوم على التوالى مقارنة بالكنترول كما ادى زيادة المادة العضوية من صفر الى 1% الى زيادة المسامية الكلية بنسبة 5.1% .

محصول الكينوا (بذور وسيقان) زاد بنسبة 22%و21% على التوالى بزيادة المادة العضوية.وعند فحص التاثير المباشر لعمق خط التنقيط والتسميد الحيوى لم يظهر تاثير معنوى ولكن كان لهم دور فعال من خلال التاثير الغير مباشر (تاثيرهم على كل من النفاذية – المسامية الكلية – تنفس التربة وتصاعد غاز ثنى اكسيد الكربون) فقد لوحظ ان كل تحسن 1% للنفاذية يؤدى الى زيادة6.5 كجم/ف و8 كجم/ف لكل من محصول البذور والسيقان على التوالى.

تصاعد غاز ثانى اكسيد الكربون لم يكن له تاثير معنوى على المحصول ولكن عندماحدث تداخل بين المادة العضوية ونفاذية الهواء كان هناك تاثير معنوى.

كفاءة الاستهلاك المائى تاثرت معنويا بالمادة العضوية وكان معامل الارتباط 0.554 و0.589 على التوالى.

كانت علاقة الارتباط بين عمق الرى وتصاعد غاز ثانى اكسيد الكربون غير معنوية فى حين كانت علاقة الارتباط بين الماء المستهلك وكفاءة الاستهلاك المائى علاقة معنوية ووصلت 0.505 فى حالة محصول البذور.