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The Role of Organic Fertilization in Raising Potato Productive Efficiency and Water Productivity under the Conditions of Organically Poor Sandy Soil

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Abstract

Water application efficiency, soil organic matter content, water stress inside root zone, EC soil, yield, quality and water productivity of potato were investigated under arid and poor sandy soils in Egypt during two growing seasons 2018/2019 and 2019/2020 at the Research Farm of National Research Center (NRC). Water application efficiency and the average of soil organic matter content were increased by increasing the amount of organic fertilizers applied. The values of the yield of potato and protein content and carbohydrates content were increased by increasing the amount of organic N-fertilizers applied up to 50% and it decreased with the continued increase in organic N-fertilizers addition. The values of the yield of potato were increased by increasing the amount of organic N-fertilizers applied up to 50% and it decreased with the continued increase in organic N-fertilizers addition. There are a set of positive effects resulted from the increase in the addition of N-organic fertilizers against one negative effect. The increase in the addition of organic N-fertilization led to an increase in the organic matter and thus increased the water application efficiency, thus a decrease in water stress and a decrease in the accumulation and concentration of salts in the area of root proliferation until reaching the best proportion of organic N-fertilization when adding 50% with 50% of mineral nitrogen fertilization, while the productivity decreased when continuing with the percentage of addition of organic N-fertilization until reaching the lowest values of productivity when organic N-fertilization is 100% where, the total percentage of nitrogen available (NO_3) in the area of root proliferation decreased after the percentage of organic fertilization exceeded 50% and the negative effect of nitrogen fertilization stress on the decrease in potato productivity. Finally, the results of the study concluded that, the necessity of relying on organic nitrogen fertilization in addition to mineral nitrogen fertilization at 50% organic to 50% mineral without any significant impact on the productivity and quality characteristics of potato under arid and sandy soils conditions in Egypt.

Keywords: *Organic N-fertilization, Water application efficiency, Yield, Water productivity, Water stress, Potato*

Introduction

Water scarcity is one of the serious problems facing the production of field crops in arid Egypt, which is located in the most arid regions in the world, where the annual precipitation ranges from 200 to 280 mm. Therefore, it is necessary to develop innovative technologies that can be effective to save water .In Egypt, the agricultural sector faces a serious challenge under conditions of irrigation water shortage [1]. In arid and semi-arid areas with densely populated and limited freshwater, there is great pressure on the agricultural sector to reduce consumption of the limited freshwater resources for irrigation in other sectors [2]. Therefore, the goal has always been to increase food production with less water, which can be achieved by increasing crop water productivity. The United Nations agrees that in the next few years Egypt will face a water crisis of an undesirable scale that will be negative, which will increase with the increase in population growth [3]. Increased competition for scarce water resources is in competition with new irrigation technologies to increase water productivity and improve crop productivity and quality characteristics [4], [5]. Water resources in Egypt are still suffering from significant limitations compared to the increasing demand for water. Therefore, improving water management in both new and old lands is a major component of agricultural development. Water productivity of crops in Egypt is critical, given the limited water resources,

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rainfall, and very limited and low rainfall factors [6], [7]. The application of modern irrigation methods and the new technologies associated with them is an important and necessary case for Egypt [8].

Improving and increasing crop productivity is one of the most important issues in the world under conditions of sustainable agriculture [9]. Other factors such as increased use of chemical fertilizers, deep tillage, and unsustainable agricultural practices have led to an increase in plant production at the expense of soil, which has negatively affected soil fertility. Under these conditions, these agricultural practices have resulted in decreased soil organic matter (SOM) content, soil biodiversity, and degradation of soil physical properties (for example, increased soil erosion, sediment transport, pollution of surface and groundwater [10], [11]. As an alternative way of preserving the environment, several studies have suggested the use of organic soil amendment approach and method which is considered the best way to maintain the production of economically viable crops with minimal environmental pollution. Several studies have stated that in order to ensure a high yield, it is important that the soil remains fertile by providing the appropriate elements, as it became evident the importance of adding organic matter to increase biological activities and improve soil acidity, to deeply loosen the soil in order to improve the water and air system, etc. [12]. Promoting microorganisms through the application of bio-fertilization is a healthy choice of chemical composting. The preparation of microbial organisms including the living cells of many microorganisms that are able to convert plant nutrients in the soil from the unavailable form to the available form is called bio-fertilizer.Consequently, salt will increase crop yields by about 30% at an effective cost as well as provide good biological activity conditions for the soil [13]. The appropriate SOM level through the constant addition of sources of organic matter such as compost is important, which is easily oxidized in Mediterranean conditions [14]. Decomposition of plant residues has been reported to release significant levels of nutrients and organic matter into the soil [15]. [16] studied the effect of organic addition and chemical fertilizers on cucumber yield and fruit properties. It was found that the organic treatment (10 m^3 compost / 540 m^2) gave a much larger early yield and could be exported than the inorganic (chemical) treatment. Thus, SOM depletion is the main cause of ecosystem degradation and loss of ecosystem resilience [17]. The high cost of mineral fertilizers, low application efficiency and low availability make crop production difficult to manage [18]. Integrated Plant Nutrition Management (IPNM) could be the best alternative approach to improving crop production and sustainable soil health. Under IPNM, the various nutrient sources are collectively used in a sustainable way. The combination of organic manure and mineral fertilizers can help improve soil properties and reduce nutrient leaching, thus increasing the effectiveness of mineral fertilizers, [19], [20], [21]. Improving soil compost retention capacity, cation exchange capacity, soil aeration, seed germination and plant growth [22]. Likewise, green manure crops such as Sesbania aculeate and cluster beans (Cyamopsis tetragonoloba) increased soil organic matter content, nutrient availability, and soil fertility by improving the physical and biochemical properties of the soil as well as reducing nutrient losses [23], [24]. Spanish tillage as green manure improved the rice yield [25]. Moreover, the incorporation of agricultural manure and green manure with mineral fertilizers in the crop pattern of wheat, rice and wheat increased the yields of both crops [26] . Another study indicated a significant increase in wheat yield by using natural fertilizers and mineral fertilizers together [27]. Healthy plants actually produce the highest yield, which is not possible without healthy soil and balanced fertilization. Using farm manure is a relatively common practice for green manure. Soil nutrient dynamics may vary depending on the type of organic source as well as the rate of mineral fertilizer.

Potatoes are the largest horticultural exports in the two banks in recent years, as the European Union has acquired about 70% - 90% of Egyptian potato exports, as the total value of potato exports to the United Euro is about 65 million Euros, or about 43.5% of Egyptian agricultural exports to the Euros united [28]. The aim of the research was to reduce the harmful effect of mineral fertilization, increase sustainable organic fertilization and reduce water stress, and increase the activity of the vital component within the root spread area under the conditions of organically poor sandy lands while preserving the same productivity values as they were when full mineral fertilization.

Material and methods

Experimental site: Field experiments were conducted during 2018/2019 and 2019/2020 at the research farm of National Research Center (NRC) (latitude 30o 30' 1.4" N, longitude 30º 19' 10.9" E, and 21 m+MSL (mean sea level) at Nubaryia Region, Al Buhayrah Governorate, Egypt. The experimental area has an arid climate with cool winters and hot dry summers. The data of maximum and minimum temperature, relative humidity and wind speed were obtained from the local weather Station at El-Nubaryia Farm.

Physical and chemical properties of the soil and irrigation water: The mechanical analyses of the soil of the experimental site showed 86.3% coarse and fine sand, 8.4% silt, and 5.3% clay, classified as sandy soil. Irrigation water was obtained from an irrigation channel passing through the experimental area. The irrigation water had a pH of 7.35 and an electrical conductivity (EC) of 0.41 dS m^{-1}. The main physical and chemical properties of organic fertilizer and irrigation water were determined in situ and in the laboratory at the beginning of the field trial (Table 1).

Table (1): Chemical analysis of organic fertilizer and irrigation water.

Item		Compost, 2018/2019	Compost, 2019/2020	Irrigation water
pH		5.92	5.87	7.37
EC, (ds/m)		0.70	0.68	0.40
Anions (meq./L)	HCO_3^-&CO_3^{2-}	1.20	1.23	0.11< 0.01
	Cl^-	3.50	3.48	2.73
	SO_4^{2-}	2.90	2.96	1.34
Cation (meq./L)	Ca++	2.00	1.98	1.04
	K+	2.20	2.14	0.22
	Mg+	1.00	1.10	0.52
	Na+	2.40	2.45	2.42
Organic Matter (%)		97.6	96.4	------
Moisture Content (%)		18	19	------
Nitrogen (%)		**0.91**	**0.93**	< 0.01
C/N ratio		30:1	30:1	------
Phosphorus (%)		0.85	0.82	------
Potassium (%)		0.90	0.93	0.22

EC: Electrical Conductivity, C/N ratio: The ratio between carbon and Nitrogen in compost

Experimental design: The experiment was established with random block design having three replicates. The main plots included eleven cases for organic N-fertilization ratio [(OFR1:100%MN+0%ON), (OFR2:90%MN+10%ON), (OFR3:80%MN+20%ON), (OFR4:70%MN+30%ON), (OFR5:60%MN+40%ON), (OFR6:50%MN+50%ON), (OFR7:40%MN+60%ON), (OFR8:30%MN+70%ON), (OFR9:20%MN+80%ON), (OFR10:10%MN+90%ON) and (OFR11:0%MN+1000%ON)]. Where, MN: Mineral Nitrogen; ON: Organic Nitrogen as shown in Figure (1).

Pumping system, control pressure head and filtration unit: The irrigation system consisted of a centrifugal pump with 45 m^3h^{-1} discharge rate, a screen filter and a backflow prevention device, a pressure regulator, pressure gauges, control valves and a flow meter. The main line, a polyvinyl chloride (PVC) pipe with 110 mm of ∅, conveyed the water from the source to the main control points in the field. Sub-main lines, connected to the main line, were PVC pipes with 75 mm of ∅. Manifold lines, polyethylene (PE) pipes of 63 mm of ∅ were connected to the sub-main line and control valves and discharge gauges. The emitters were built in lateral PE tubes, 50 m long and 16 mm. Emitter discharge was 4 $l.h^{-1}$ at 1.0 bar operating pressure, spacing between the emitters was 30 cm and sprinkler is an impact sprinkler 3/4" diameter with a discharge of 1.17 m^3 h^{-1}, with 100 cm of riser height and wetted radius of 12 m and working pressure of 250 kPa.

Fertilization method: according to analyses of compost content, 0.91 % nitrogen and potato requirements from nitrogen was 150 kg nitrogen/ fed. [100% chemical nitrogen fertilizer in the form of ammonium nitrate (33.5% N)]. This mean the total amount from compost =150/9.1= 16.48 ton/fed. and more than 50% from applied compost will analyzed during the next year, this mean the total amount from compost at least 32.96 ton/fed. The compost was applied 20 days before planting. The scheduling of the integrated nitrogen fertilization for all treatments according to the previous information is shown in the Table (2).

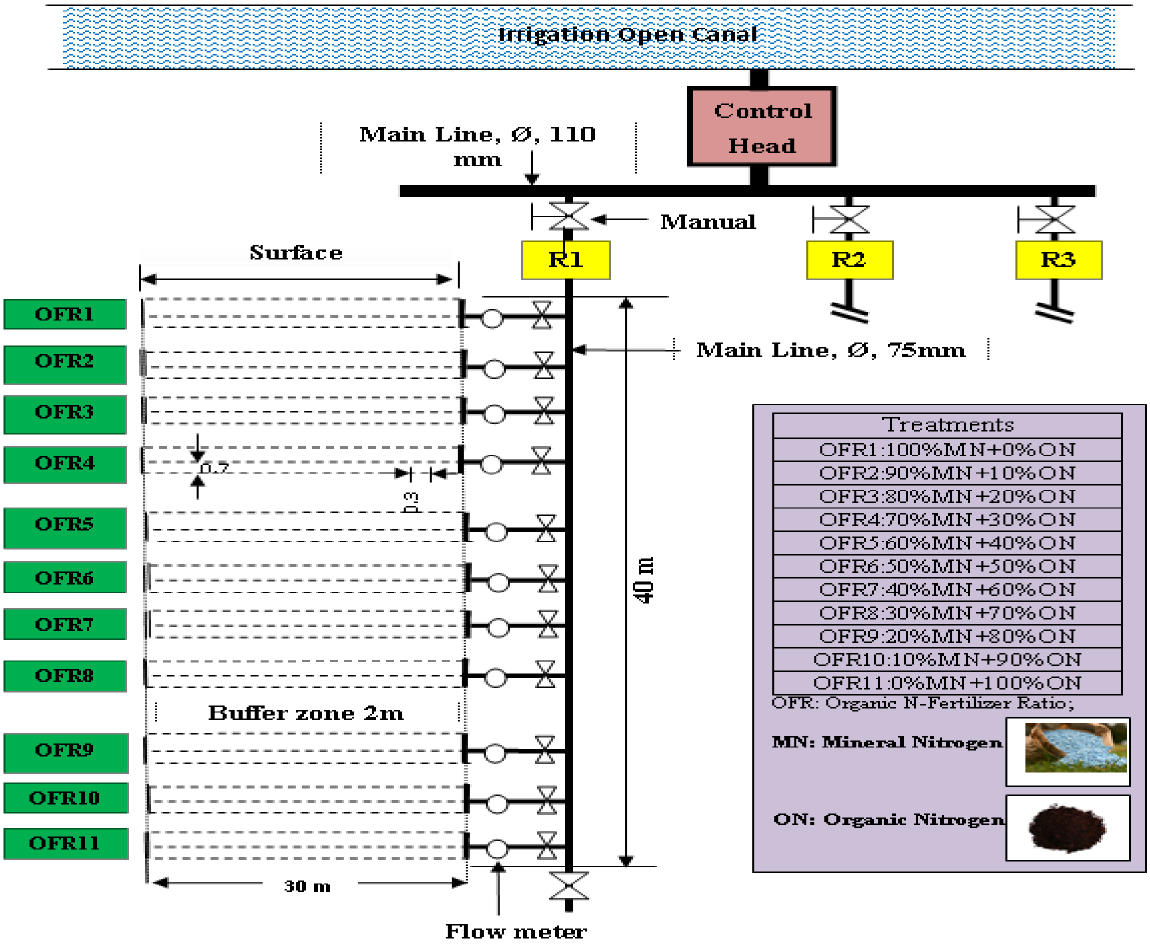


Figure (1): Layout of experimental design.

Table (2): Distribution treatments of the experimental design.

Treatments	**2018/2019 and 2019/2020**	MN, kg$_{ammonium\ nitrate\ (33.5\%N)}$/fed	ON, kg/fed, 2018/2019	ON, kg/fed, 2019/2020
OFR1:100%MN+0%ON		448	0	0
OFR2:90%MN+10%ON		403.2	3296	3226
OFR3:80%MN+20%ON		358.4	6592	6452
OFR4:70%MN+30%ON		313.6	9888	9678
OFR5:60%MN+40%ON		268.8	13184	12904
OFR6:50%MN+50%ON		224	16480	16130
OFR7:40%MN+60%ON		179.2	19776	19356
OFR8:30%MN+70%ON		134.4	23072	22582
OFR9:20%MN+80%ON		89.6	26368	25808
OFR10:10%MN+90%ON		44.8	29664	29034
OFR11:0%MN+100%ON		0	32960	32260

OFR: Organic N-Fertilizer Ratio; MN: Mineral Nitrogen; ON: Organic Nitrogen; 150 kg nitrogen/ fed. in the form of ammonium nitrate (33.5% N)= 448 kg/fed; 100% ON =32.96 ton/fed.=32960 kg/fed. for season 2018/2019 and 100% ON =32.26 ton/fed.=32260 kg/fed. for season 2018/2019

Irrigation requirements: Irrigation water requirements of potato under drip irrigation system were calculated (1800 and 1700 m^3/fed. for 2018/2019 and 2019/2020 seasons, respectively) [29] according to the following equations 1.

$$IRg = [(ET_o \times Kc \times Kr) / I_E] - R + LR \quad ....(1)$$

Where: IRg: Gross irrigation requirements, mm/day; ET_O: Reference evapotranspiration, mm/day, Kc: Crop factor of potato (FAO-56), Kr: Reduction factor; I_E: Irrigation efficiency, %, R: Rainfall, (mm), LR: Amount of water required for the leaching of salts, mm

Evaluation parameters:

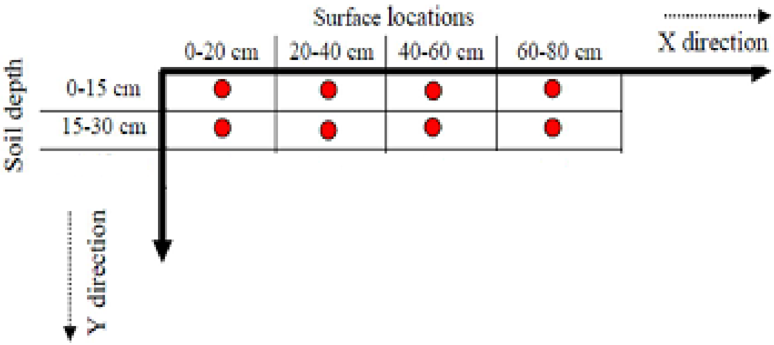
Water application efficiency: Application efficiency of irrigation water (AE_{IW}) is the actual storage of water in the root zone to the water applied to the field. AE_{IW} was calculated using equation 2:

$$AE_{IW} = Ds/ Da \ldots\ldots\ldots\ldots \quad (2)$$

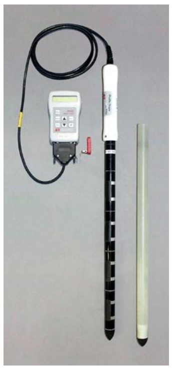
Where AE_{IW} is the application efficiency of irrigation water, %, Da is the depth of applied water (mm), Ds is the depth of stored water in the root zone, mm by equation 3.

$$Ds = (\theta 1 - \theta 2) * d * \rho \ldots\ldots\ldots \quad (3)$$

Where: d is the soil layer depth (mm), θ1 is the average of soil moisture content after irrigation (g/g) in the root zone, θ2 is the average of soil moisture content before irrigation (g/g) in the root zone at peak water requirements and ρ is Relative bulk density of soil (dimensionless). as shown in Figure (2).



Locations of soil moisture content before and after irrigation



Profile probe

Figure (2): Locations of soil moisture content before and after irrigation and using profile probe for measuring.

Water stress inside root zone: Soil moisture was measured in effective roots zone of potato plants before irrigation and the field capacity and wilting point were taken as evaluation lines in consideration as an evaluation parameter for exposure range of the plants to water stress "WS". Measurements were taken at soil depths at mid-growth stage [30]. Soil moisture was measured by profile probe device.

Organic matter content "OMC" and Electrical conductivity "EC": The organic matter content and salt concentration were measured before planting, during plant growth stages and after harvesting potato during the two growing seasons. The average organic matter content was the sum of the values of the estimates over the number of times the estimation, and also that was done for the average salt concentration in the soil. The 12 soil samples were taken from the roots zone in each experimental plot. $EC_{1:5}$ was measured using a handheld conductivity meter (Spectrum Technologies, Inc., USA)

Yield of potato: At the harvesting time, tuber yield of potato for each plot were harvested and total yield were determined in kg/m^2 and then converted to ton/fed.

Water productivity: *"*WP_{potato}*":* The water productivity of potato was calculated according to according to [31] as follows by equation 4:

$$WP_{potato}= Ey/Ir\ldots\ldots\ldots\ldots(4)$$

Where WP_{potato} is water productivity of potato (kg_{potato} m^{-3}_{water}), Ey is the economical yield (kg_{potato}/fed); Ir is the amount of applied irrigation water (m^3_{water}/fed.).

Quality traits: Total nitrogen (TN) was measured using Kjeldahl's method, and total crude protein (TCP) was determined by multiplying TN-content in grains by 6.25 according to [32]. The phenol-sulfuric acid method was used for determination of total carbohydrates (TC) [33].

Statistical analysis: The obtained data were subjected to analysis of variance (ANOVA) according to [34] using Mstat-c Software Program. Duncan's Multiple Range Test were used compare between means according to [35] at probability 0.05.

Results and discussion

Water application efficiency, water stress inside root zone, soil organic matter content, soil electrical conductivity, yield, quality and water productivity of potato were investigated under organic N-fertilization ratio under arid and sandy soils in Egypt.

Water Application Efficiency

Figure (3) indicated that, the values of water application efficiency “WAE” were increased by increasing the amount of organic N-fertilizers applied. The lowest values were at zero adding for organic N-fertilizers and the highest values were at adding 100% of organic N-Fertilizers.

Water application efficiency “WAE” were increased by increasing the amount of organic N-fertilizers applied. This due to that, increasing the content of organic matter in the sandy soils by increasing the organic fertilizers amount will improve the ability of the soil to retain moisture in the area of root zone and reducing the deep percolation of irrigation water, which led to an increase in the water application efficiency by the increasing nitrogenous organic fertilizers. This result agreement with [36] and [37].

Figure (4) indicated that, the values of water stress inside root zone “$WS_{root\ zone}$” were decreased by increasing the amount of organic N-fertilizers applied. The highest values were at zero adding for organic N-fertilizers and the lowest values were at adding 100% of organic N-Fertilizers.

$WS_{root\ zone}$ before irrigation were decreased by increasing the amount of organic N-fertilizers applied. This due to that, increasing the content of organic matter in the sandy soils and increasing the content of organic matter in the sandy soil will improve the ability of the sandy soil to retain moisture in the inside root zone , which led to an decrease in the $WS_{root\ zone}$ which reflected positively on the health status of potato plants without the slightest water stress.

Water Stress inside Root Zone:

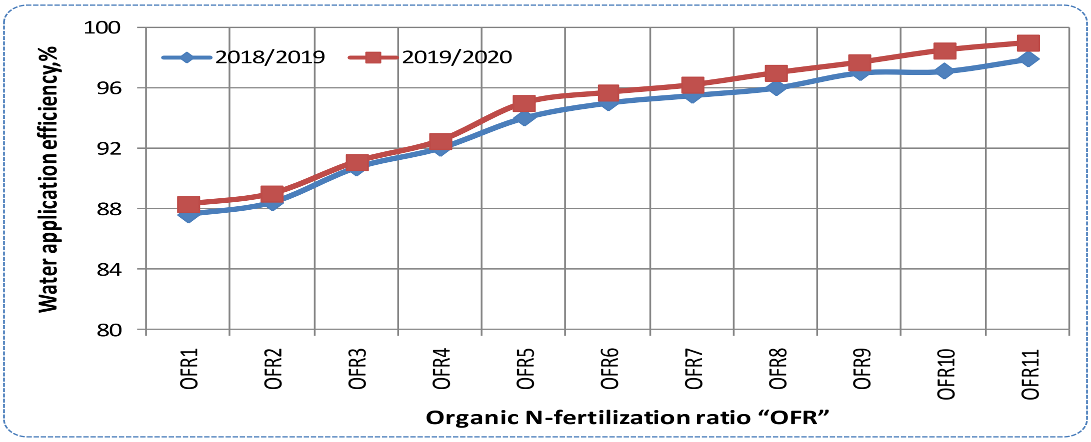


Figure (3): Effect of organic N-fertilization ratio “OFR” on the water application efficiency (OFR1:100%MN+0%ON; OFR2:90%MN+10%ON; OFR3:80%MN+20%ON; OFR4:70%MN+30%ON; OFR5:60%MN+40%ON; OFR6:50%MN+50%ON; OFR7:40%MN+60%ON; OFR8:30%MN+70%ON; OFR9:20%MN+80%ON; OFR10:10%MN+90%ON; OFR11:0%MN+100%ON; MN: Mineral Nitrogen; ON: Organic Nitrogen)

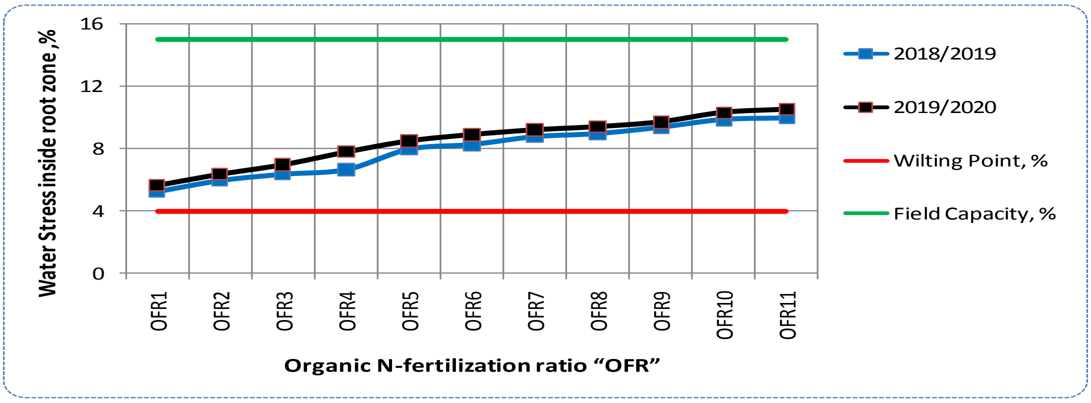


Figure (4): Effect of organic N-fertilization ratio “OFR” on the water stress in the root zone

(OFR1:100%MN+0%ON; OFR2:90%MN+10%ON; OFR3:80%MN+20%ON; OFR4:70%MN+30%ON; OFR5:60%MN+40%ON; OFR6:50%MN+50%ON; OFR7:40%MN+60%ON; OFR8:30%MN+70%ON; OFR9:20%MN+80%ON; OFR10:10%MN+90%ON; OFR11:0%MN+100%ON; MN: Mineral Nitrogen; ON: Organic Nitrogen)

Soil Organic Matter Content

Figure (5) indicated that, the values of the average of soil organic matter content during growing season "ASOMC" were increased by increasing the amount of organic fertilizers applied. The lowest values were at zero adding for organic N-fertilizers and the highest values were at adding 100% of organic N-Fertilizers. This is a logical thing that does not need evidence, as the percentage of organic matter in the nitrogenous organic fertilizers added to 97.6 % it is according to the compost analysis attached above, and this increase in organic matter appears when it is added to poor sandy lands.

Soil Electrical Conductivity

Figure (6) indicated that, the values of the average of electrical conductivity of soil during growing season "$EC_{root\ zone}$ " were decreased by increasing the amount of organic N-fertilizers applied. The lowest values were at 100% of organic N-Fertilizers and the highest values were at no adding. This is due to the low rate of evaporation from the soil surface resulting from the increase of organic matter in sandy soil that loves to retain irrigation water within the potato root spread area.

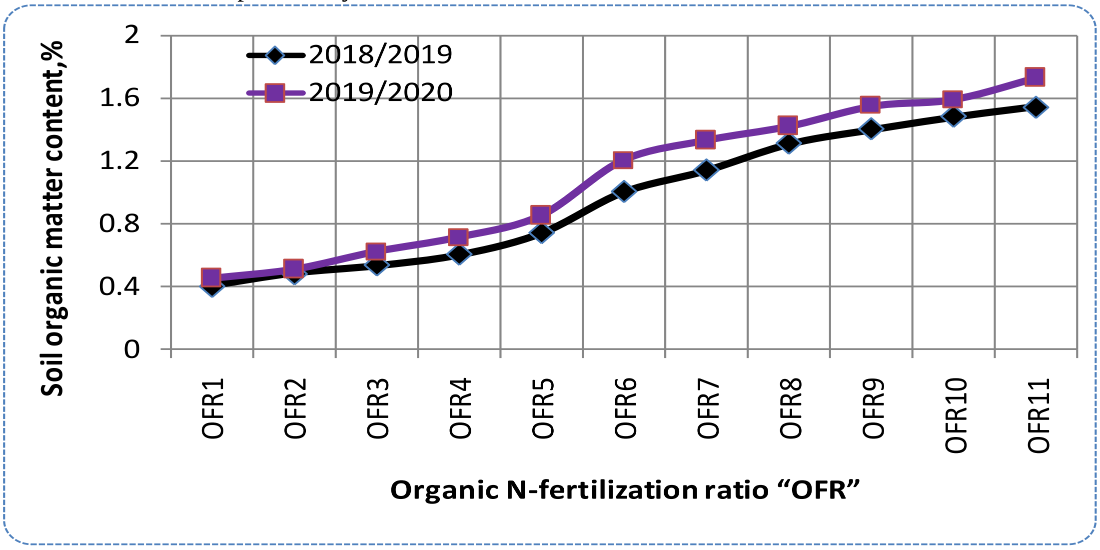


Figure (5): Effect of organic N-fertilization ratio "OFR" on the soil organic matter content.

(OFR1:100%MN+0%ON; OFR2:90%MN+10%ON; OFR3:80%MN+20%ON; OFR4:70%MN+30%ON; OFR5:60%MN+40%ON; OFR6:50%MN+50%ON; OFR7:40%MN+60%ON; OFR8:30%MN+70%ON; OFR9:20%MN+80%ON; OFR10:10%MN+90%ON; OFR11:0%MN+100%ON; MN: Mineral Nitrogen; ON: Organic Nitrogen)

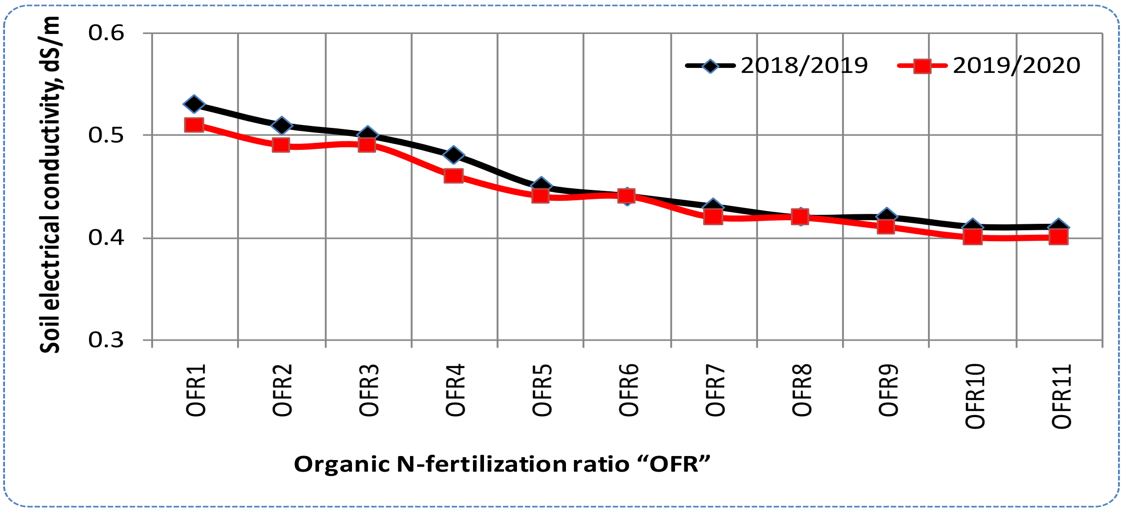


Figure (6): Effect of organic N-fertilization ratio "OFR" on the soil electrical conductivity

(OFR1:100%MN+0%ON; OFR2:90%MN+10%ON; OFR3:80%MN+20%ON; OFR4:70%MN+30%ON; OFR5:60%MN+40%ON; OFR6:50%MN+50%ON; OFR7:40%MN+60%ON; OFR8:30%MN+70%ON; OFR9:20%MN+80%ON; OFR10:10%MN+90%ON; OFR11:0%MN+100%ON; MN: Mineral Nitrogen; ON: Organic Nitrogen)

Yield of Potato

Figure (7) and Table (3) indicated that, the values of the yield of potato "Y_{potato}" were increased by increasing the amount of organic N-fertilizers applied up to 50% and then, it decreased with the continued increase in organic N-fertilizers addition as a complementary organic N-fertilizer to mineral fertilization. The lowest values were occurred at adding 100% organic N-fertilizers with zero mineral N-fertilizers and the highest values of Y_{potato} were at adding 50% organic N-fertilizers with 50% mineral N-fertilizers.

The values of the Y_{potato} were increased by increasing the amount of organic N-fertilizers applied up to 50% and it decreased with the continued increase in organic N-fertilizers addition. There are a set of positive effects resulted from the increase in the addition of N-organic fertilizers against one negative effect. The increase in the addition of organic N-fertilization led to an increase in the organic matter and thus increased the water application efficiency, thus a decrease in water stress and a decrease in the accumulation and concentration of salts in the area of root proliferation until reaching the best proportion of organic N-fertilization when adding 50% with 50% of mineral nitrogen fertilization, while the productivity decreased when continuing with the percentage of addition of organic N-fertilization until reaching the lowest values of productivity when organic N-fertilization is 100% where, the total percentage of nitrogen available (NO_3) in the area of root proliferation decreased after the percentage of organic fertilization exceeded 50% and the negative effect of nitrogen fertilization stress on the decrease in potato productivity.

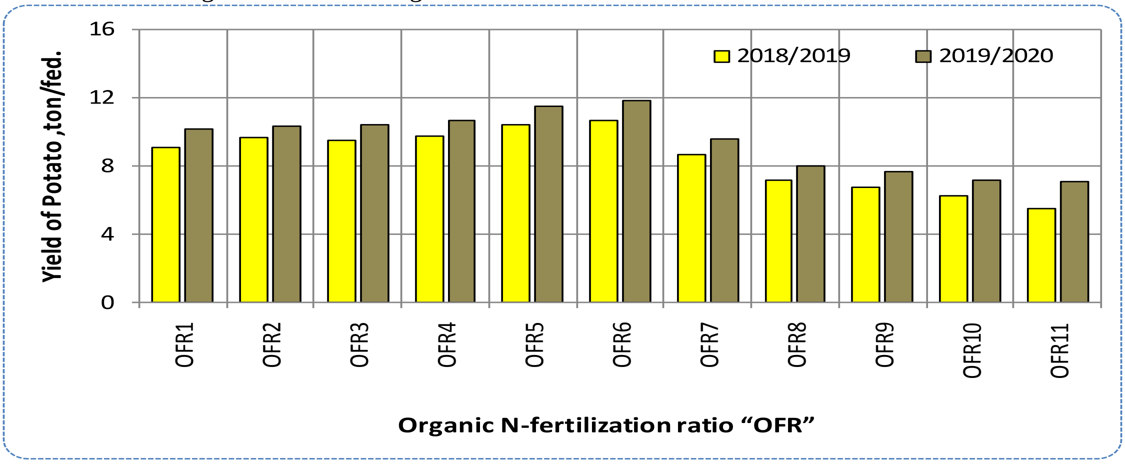


Figure (7): Effect of organic N-fertilization ratio "OFR" on the on the yield of potato.

(OFR1:100%MN+0%ON; OFR2:90%MN+10%ON; OFR3:80%MN+20%ON; OFR4:70%MN+30%ON; OFR5:60%MN+40%ON; OFR6:50%MN+50%ON; OFR7:40%MN+60%ON; OFR8:30%MN+70%ON; OFR9:20%MN+80%ON; OFR10:10%MN+90%ON; OFR11:0%MN+100%ON; MN: Mineral Nitrogen; ON: Organic Nitrogen)

Table (3): Effect of organic N-fertilization ratio on the yield and water productivity of potato for two seasons

Treat.	**2018/2019**								**2019/2020**							
	Yield (ton/fed.)				**WP (kg/m^3)**				**Yield (ton/fed.)**				**WP (kg/m^3)**			
OFR1	9.100	cd	±	0.361	5.100	cd	±	0.100	10.200	b	±	0.100	6.033	b	±	0.058
OFR2	9.633	bc	±	0.153	5.333	bc	±	0.058	10.333	b	±	0.153	6.067	b	±	0.058
OFR3	9.467	bc	±	0.153	5.267	bc	±	0.058	10.433	b	±	0.208	6.100	b	±	0.100
OFR4	9.733	b	±	0.208	5.400	b	±	0.100	10.633	b	±	0.153	6.200	b	±	0.100
OFR5	10.433	a	±	0.379	5.800	a	±	0.173	11.500	a	±	0.436	6.767	a	±	0.231
OFR6	10.700	a	±	0.265	5.967	a	±	0.153	11.867	a	±	0.153	7.000	a	±	0.100
OFR7	8.700	d	±	0.557	4.867	d	±	0.306	9.567	c	±	0.603	5.633	c	±	0.351
OFR8	7.133	e	±	0.153	3.967	e	±	0.116	8.000	d	±	0.300	4.700	d	±	0.200
OFR9	6.767	ef	±	0.153	3.767	e	±	0.058	7.700	d	±	0.265	4.533	d	±	0.153
OFR10	6.267	f	±	0.208	3.467	f	±	0.116	7.167	e	±	0.153	4.200	e	±	0.100
OFR11	5.467	g	±	0.404	3.033	g	±	0.252	7.100	e	±	0.002	4.200	e	±	0.000

a is the largest value and h is the lowest value and The means followed by the same alphabetical letters were not significantly different at the probability level of 0.05, Treatments; WP_{Potato}: Water productivity of potato; MN: Mineral Nitrogen; ON: Organic Nitrogen; (OFR1:100%MN+0%ON; OFR2:90%MN+10%ON; OFR3:80%MN+20%ON; OFR4:70%MN+30%ON; OFR5:60%MN+40%ON; OFR6:50%MN+50%ON; OFR7:40%MN+60%ON; OFR8:30%MN+70%ON; OFR9:20%MN+80%ON; OFR10:10%MN+90%ON; OFR11:0%MN+100%ON; MN: Mineral Nitrogen; ON: Organic Nitrogen)

Protein and Carbohydrates Content

Figures (8 , 9) and Table (4) indicated that, the values of the protein and carbohydrates content of potato "PCC_{potato}" were increased by increasing the amount of organic N-fertilizers applied up to 50% and it decreased with the continued increase in organic N-fertilizers addition. The lowest values were at adding 100% organic N-fertilizers with zero mineral N-fertilizers and the highest values of PPC_{potato} were at adding 50% organic N-fertilizers with 50% mineral N-fertilizers. PCC_{potato} was affected by the same factors that affected the productivity values, where the nitrogen uptake increased with the increase in the addition of organic nitrogen fertilization until it reached 50% and with the continuation of the increase, there was a limitation in the availability of the total amount of nitrogen available (NO_3) in the root spread area.

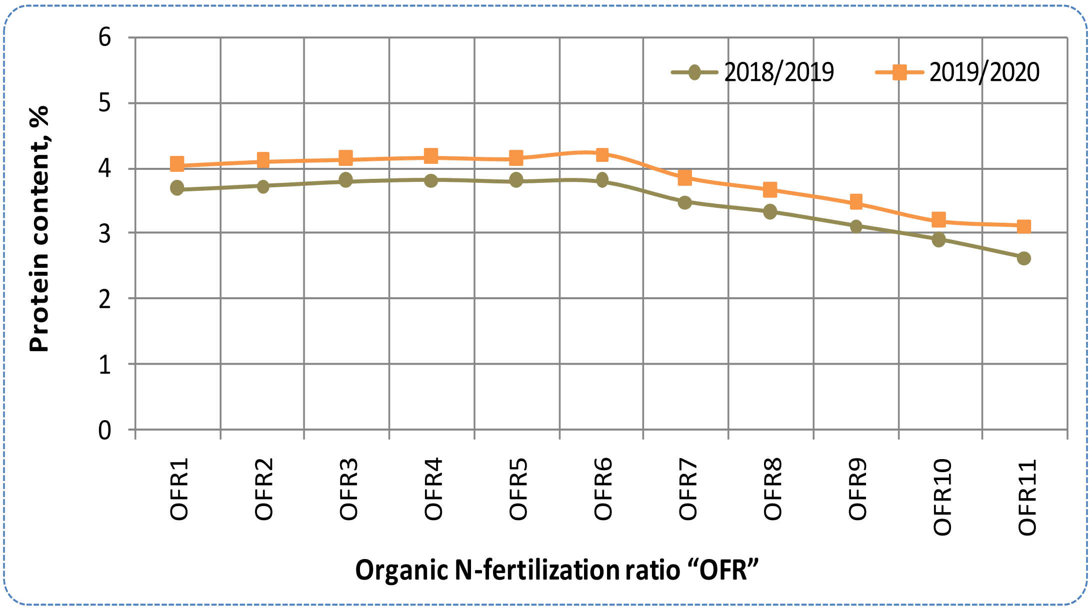


Figure (8): Effect of organic N-fertilization ratio "OFR" on the on the protein content of potato.

(OFR1:100%MN+0%ON; OFR2:90%MN+10%ON; OFR3:80%MN+20%ON; OFR4:70%MN+30%ON; OFR5:60%MN+40%ON; OFR6:50%MN+50%ON; OFR7:40%MN+60%ON; OFR8:30%MN+70%ON; OFR9:20%MN+80%ON; OFR10:10%MN+90%ON; OFR11:0%MN+100%ON; MN: Mineral Nitrogen; ON: Organic Nitrogen)

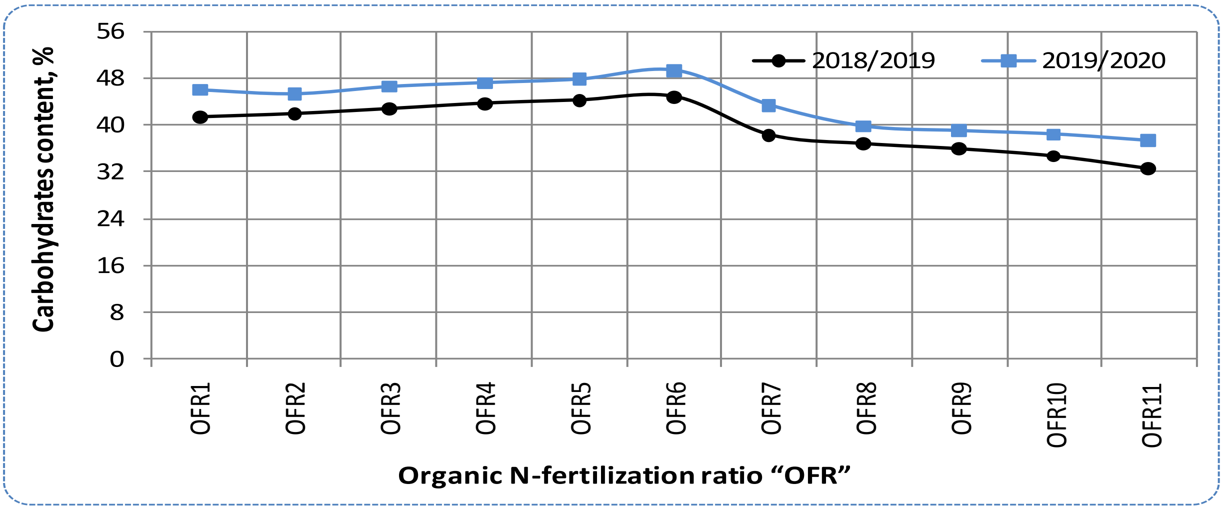


Figure (9): Effect of organic N-fertilization ratio "OFR" on the on the carbohydrate content.

(OFR1:100%MN+0%ON; OFR2:90%MN+10%ON; OFR3:80%MN+20%ON; OFR4:70%MN+30%ON; OFR5:60%MN+40%ON; OFR6:50%MN+50%ON; OFR7:40%MN+60%ON; OFR8:30%MN+70%ON; OFR9:20%MN+80%ON; OFR10:10%MN+90%ON; OFR11:0%MN+100%ON; MN: Mineral Nitrogen; ON: Organic Nitrogen)

Table (4): Effect of organic N-fertilization ratio on the protein and carbohydrates content of potato for seasons 2018/2019 and 2019/2020

Treat.	2018/2019								2019/2020							
	Protein content %				Carbohydrates %				Protein content %				Carbohydrates %			
OFR1	3.673	b	±	0.047	41.400	d	±	0.755	4.036	b	±	0.015	46.00	cd	±	0.000
OFR2	3.723	ab	±	0.025	41.967	cd	±	0.153	4.093	ab	±	0.045	45.33	d	±	0.208
OFR3	3.790	a	±	0.020	42.833	bc	±	1.002	4.130	ab	±	0.020	46.60	bcd	±	0.557
OFR4	3.816	a	±	0.015	43.767	ab	±	0.154	4.156	ab	±	0.015	47.26	bc	±	0.155
OFR5	3.796	a	±	0.040	44.333	a	±	0.404	4.140	ab	±	0.045	47.90	b	±	0.458
OFR6	3.790	a	±	0.050	44.900	a	±	0.624	4.210	a	±	0.026	49.43	a	±	0.651
OFR7	3.480	c	±	0.040	38.300	e	±	1.015	3.836	c	±	0.075	43.36	e	±	2.676
OFR8	3.316	d	±	0.040	36.767	f	±	0.251	3.653	d	±	0.070	39.70	f	±	0.300
OFR9	3.110	e	±	0.065	35.867	f	±	0.351	3.463	e	±	0.155	38.93	f	±	0.153
OFR10	2.893	f	±	0.941	34.600	g	±	1.015	3.186	f	±	0.083	38.333	fg	±	0.306
OFR11	2.630	g	±	0.908	32.433	h	±	0.874	3.110	f	±	0.000	37.200	g	±	0.721

a is the largest value and h is the lowest value and The means followed by the same alphabetical letters were not significantly different at the probability level of 0.05, T: Treatments; MN: Mineral Nitrogen; ON: Organic Nitrogen; (OFR1:100%MN+0%ON; OFR2:90%MN+10%ON; OFR3:80%MN+20%ON; OFR4:70%MN+30%ON; OFR5:60%MN+40%ON; OFR6:50%MN+50%ON; OFR7:40%MN+60%ON; OFR8:30%MN+70%ON; OFR9:20%MN+80%ON; OFR10:10%MN+90%ON; OFR11:0%MN+100%ON; MN: Mineral Nitrogen; ON: Organic Nitrogen)

Conclusion

The results of this study concluded that, the necessity of relying on organic nitrogen fertilization in addition to mineral nitrogen fertilization at 50% organic nitrogen to 50% mineral without any significant impact on the productivity and quality characteristics of potato under arid and sandy soils conditions in Egypt.

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