The Impact of Adsorbent Ameliorants on some Physical Properties and Potato Yield in Sandy Soil Under Deficit Irrigation Water

Sahar M. Ismail [1]; and Salah A. E. El-cossy[2]

ABSTRACT

Sandy soils have characterized by low soil water storage and poor fertility. This study is conducted in the Suez Canal region, to improve and evaluate some soil physical properties, potato yield components, quality and economic returns as a result of addition soil adsorbent ameliorants (PPA, PAM & humic acid (HA)) and mixtures of each with the others plus control treatment under deficit irrigation water regimes (100, 80 and 50 % of crop water requirements, CWR) with three replicates. The results showed that the mixed ameliorant treatment of PAM plus humic acid obtained the highest soil moisture content at 20-40 cm of soil depth. Soil ameliorants significantly improved soil water storage and soil aggregate size distribution ($P \leq 0.01$). The results also showed that the deficit irrigation water regimes led to increase in the mass proportion of large macro-aggregates (> 2.0 mm) and micro-aggregates (< 0.25 mm) in all soil depths. The mixed ameliorant treatment of PAM + humic acid produced highest fresh tuber yield and commercial tuber proportion. Water use efficiency (WUE) values were higher with the mixed than single ameliorants under different deficit irrigation water regimes. The applied of PPA or PAM alone had a higher economic return than the mixed treatments of PPA or PAM. The economic return not detected when the humic acid applied alone.

Key words: Ameliorants, Potatoes, Deficit irrigation water, Soil physical properties and economic return.

INTRODUCTION

The sustainability of crop production in arid and semi-arid areas faces its most significant threats from water scarcity and drought due to the impacts of global climate change. These challenges have a potential to create severe socioeconomic environment (Rivero, et al., 2007). In addition, the water shortage problem in these areas led to soil properties deterioration and may desertification. These environmental challenges are affected by the interaction between natural climate change factors and dam-related human disruptions through improper land utilization and management (Biro, et al., 2013 and LiYQ, et al., 2012). Arid and semi-arid regions represent about one-third of the world's total land area (Archibold, 1995). Great evaporation rates, irregular dry periods, frequent droughts, episodes of intensive rainfall followed by extended dry periods, and low fertility of soil that are prone to erosion are most challenges face the agricultural ecosystems in arid and semi-arid areas (Falkenmark and Rockström, 2004). Governments and academic staff should deal with climate change, increasing population, and growing water demands, which will led to water scarcity to avoid a significant gap between the global food supply and population demand which expected to reach 10 billion in the twenty-first century (Easterling, 2007). Applying water-absorbing materials such as poly-acrylamide (PAM) and potassium poly-acrylate (PPA) in sandy soil could consider as a viable approach and tactic for addressing issues arising from inadequate and sporadic rainfall and irrigation. These soil ameliorants have the potential to enhance the soil's physical, chemical, and nutritional attributes, available nutrient content, soil microbial activity and soil productivity (Mann, et al., 2011). It has been investigated to use synthetic chemical polymers as soil amendments to increase soil water holding capacity because they have capacity to absorb water up to 400 times of their own weight (Huttermann et al., 2009). When ameliorants are incorporated into the soil, they have the capability to store proper amounts of water and nutrients, releasing them slowly for recovering plant needs. Studies have shown that the application of polymers to sandy soil resulted in enhanced the water and fertilizer utilization by plants, improved plant growth, increased nutrient uptake, higher yields, and an improved germination process within this type of soil (Bhardwaj, et al., 2007, Islam, et al., 2011 and Dorraji, et al., 2010). Also, ameliorants may have an impact on various soil physical properties such as structure, compaction, aggregate stability, surface hardness, infiltration rate, density, and rates of evaporation (Sepaskhah and Bazrafshan-Jahromi, 2006). Trenkel (1997) reported that the studied polymers were appropriate as soil ameliorants because they are safe and non-toxic, ultimately breaking down into carbon dioxide, water, ammonia, and ions of potassium. Furthermore, those ameliorants have a five-year retention time for soil moisture and fertilizer before they degraded into non-toxic components (Holliman, et al., 2005).

DOI: 10.21608/asejaiqjsae.2023.333655

[1] Soil Chemistry and Physics Department, Desert Research Center, Egypt.
[2] Soil Conservation Department, Water Resources and Desert Soils Division, Desert Research Center, Egypt.

Received, November 20, 2023, Accepted, December 30, 2023.

Water use efficiency (WUE) is an important index for determining crop yield as a constituent of a plant's ability to combat drought stress (Blum, 2009). Effective and innovate soil-water management technique was required to ensure maximize and sustainable agriculture production in arid and semi-arid regions (Debaeke and Aboudrare, 2004). Potato (Solanum tuberosum *L.*) ranks as the world's fourth most important crop and it one of the most economically valuable staple food crops in the dry soil farming region (Spooner and Bamberg, 1994, Hayat and Ali, 2004). Growth, development, and yield formation in Qantra-Sharq are significantly hampered by seasonal drought. To enhance crop productivity, it is essential to implement more efficient water-saving agricultural practices, as higher and more stable yields rely on better crop water availability (Qin, et al. 2014). It’s clear that the use of ameliorants increased farmers' economic returns and protect agro-ecosystem (Islam, et al., 2011). Humic acid is a natural soil ameliorant which has the capability for increasing the available water supply to crops suffering water stress in arid and semi-arid soils (Turan, et al., 2011 and El-Naggar & Esmaiel, 2022). The main goal of this study was to evaluate the performance and contribution of applying soil ameliorants alone and in combination with humic acid treatments under deficit irrigation water on some physical properties of sandy soil, morphological characteristics of potato, crop production and water use efficiency (WUE) as well as economic feasibility study for using the soil ameliorants in potato production growing in sandy soil.

MATERIALS AND METHODS

Experimental Site:

The study site was located at the Desert Research Center station in El-Qantara Shark, Ismailia Governorate East Region. Its coordinates ranged between 30º47'24" and 30°52’12’’ N latitude and 32º17'24" and 32°24’36’’ E longitude.

Soil and Water analyses:

Before planting, soil samples were collected from two soil depths (0 – 20 cm and 20 – 40 cm). Aso, irrigation water samples collected from El- Salam canal. Some chemical and physical properties of soil samples and quality of irrigation of water were determined by standard methods according to Chapman and Pratt (1978). The electrical conductivity (ECe) and pH of soil samples determined in soil paste extract. The data in Table (1) reveals that the soil had moderately alkali (pH 8.00), non-saline (less than 4 dSm^{-1}), low calcium carbonate content (2.26 %) and very low organic matter (0.14 %), according to FAO criteria (FAO, 1985).

The texture class of soil samples in two depths is sandy soil (90% sand, 4.76% silt, and 5.24% clay|) with bulk density is 1.62 Mg/m3. Exchangeable Sodium Percentage (ESP) was < 15 (estimated using the formula 1.95 + 1.03 SAR according to Mohsen, 2009) and ECe <2.0 dSm-1. The quality of irrigation water was classified moderately alkaline (pH, 8.0) and moderately saline (EC, 2.65 dSm-1) as shown in Table (1). Two water-adsorbing materials were used in this experiment as soil ameliorants and the humic acid as a bio-product.

Soil Ameliorants and Humic acid characterization:

1. Potassium polyacrylate (PPA) is a granular synthetic polymer, light-yellow in color and has a high molecular weight. It possesses extremely hydrophilic and density of 1.09 Mg/m^3.
2. Polyacrylamide (PAM) is a synthetic polymer in the form of a white powder with a high molecular weight. It is extremely hydrophilic, with a density of about 1.30 Mg/m^3. The PPA and PAM purchased from Tanta for Trading and Mechanization, located in El-Sadat City.
3. Humic acid (HA) is a bio-product resulting from the decomposition of organic matter in soil. The HA was used to enhance plant resistance to water stress by dissolving it and supplied the nutrient solution for plants grown under drought conditions. Approximately 38.3% of the free humic acid used in this study. Humic acid purchased from the Tiba Company for Peanuts, located in Nagib Mahfouz Village, El-Bostan Extension, El-Beheira Governorate.

Table1. Some chemical properties of studied experimental site soil and irrigation water samples

Samples of Soil layers	pH	EC dSm^{-1}	Total $CaCO_3$ %	O.M %	Soluble cations meq/l				Soluble anions meq/l				SAR*	ESP**
					Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}		
Surface	7.88	1.46	2.15	0.12	6.54	1.26	4.20	2.64	-	0.05	8.24	6.35	3.53	5.58
Subsurface	8.12	1.13	2.36	0.16	4.94	0.92	3.62	1.82	-	0.06	6.31	4.94	2.99	5.03
Irrigation Water	8.00	2.65	-	-	13.50	0.91	7.33	4.76	-	0.05	18.72	7.73	5.49	-

*Sodium adsorption ratio (SAR) = $Na^+ / \sqrt{(Ca + Mg)/2}$

** Exchangeable Sodium Percentage (ESP, %)

Experiment design:

The experiment comprised 18 treatments. Among these, five involved two water-adsorbing soil ameliorants and humic acid, individually and in various combinations. as well as control treatment (without soil ameliorants and humic acid). These treatments were conducted under three deficit irrigation water regimes (100, 80, and 50 % of crop water requirements; CWR) using a sprinkler irrigation system. The deficit irrigation water regimes were represented in the main plots, while the soil ameliorants and humic acid treatments were represented in the sub-main plots. Each plot covered an area of 40 m^2 and a randomized complete block (RCB) factorial design was employed with three replications.

The soil ameliorants and fertilizers were incorporated into the upper 15 cm of the soil layer before planting. Each deficit irrigation water regime included the soil ameliorants, humic acid treatments, and control treatment as follows:

1. CK: Control without soil ameliorants and humic acid.
2. A1: 15 kg/fed PPA alone.
3. A2: 15 kg/fed PPA + 500 kg/fed HA.
4. A3: 15 kg/fed PAM alone.
5. A4: 15 kg/fed PAM + 500 kg/fed HA.
6. A5: 500 kg/fed HA alone.

Agronomy practices:

Sponta V. of potato was selected and planted by the planter machine on 14 February, 2021. The tillage system involved fall plowing and spring cultivation. Compound granule fertilizer (22 - 8 - 28) was applied at a rate of 140 kg fed^{-1}, providing nutrients such as 42 kg fed^{-1} N, 10 kg fed^{-1} P and 48 kg fed^{-1} K, respectively. Tuber seed pieces were planted at a soil depth 10 cm, with 20 cm spacing between plants and 30 cm spacing between rows. Manual hoeing was employed as needed to control weeds. The harvest was carried out on May 30, 2021 after 105 days from the sowing date. At maturity, both fresh tuber yield and the proportion of commercial tubers were measured. Each plot, covering a 10 m^2 area, was harvested to assess tuber yield and quality. The harvested tubers were separated based on weight into two categories: ≥ 150 g and ≤ 150 g. Tuber samples were subsequently dried for 72 hours at 70°C in a forced-air oven to determine the dry tuber yield.

Irrigation treatments:

Three deficit irrigation water regimes were imposed, with water quantities of 2200, 1760, and 1100 m^3 fed^{-1}. These quantities were determined using the Blaney and Criddle (1962) approach and corresponded to 100, 80, and 50 % of the total crop water requirements (CWR), respectively.

Calculations:

1- Soil Water Storage (SWS):

Soil moisture content (%) was determined gravimetrically at soil depths of 0–10, 10–20 and 20–40 cm on days 0, 50, 70, 90, and 105 after planting, according to ASTM (2014) standards. Soil samples collected at depths of 0 – 10 cm, 10 – 20 cm, and 20 – 40 cm at harvest underwent dry sieve analysis for soil aggregate fractionation, as described by Zhang, et al. (2003). The standard classification system proposed by Márquez, et al. (2004) was utilized to classify the soil aggregate size fractions based on particle diameter.

Soil water storage (SWS) can be calculated using Equation (1) as presented by Xu *et al.* (2014)

$$SWS = d * c * \rho s * \rho w^{-1} \quad \text{..............................} \quad (1)$$

- d = Soil depth, cm.
- c = Soil moisture content, %.
- ρs = Soil bulk density, g/cm^3.
- ρw = Water density, g/cm^3.

2- Actual evapotranspiration (ETa):

ETa is given by equation (2) accordingly, Chu *et al.* (2009).

$$ETa = 10 * \Sigma \rho i * Hi * (\theta i_1 - \theta i_2) + M + P0 + K \text{ …………} (2)$$

- ETa = Evapotranspiration, mm.
- "i" = A number of the soil layer (i = 1, 2, ..., n).
- ρi = Soil bulk density of the i^{th} soil layer, g/cm^3.
- H_i = Depth of the i^{th} soil layer, cm.
- θi_1 and θi_2 = Moisture content at the beginning and end of the time period for the i^{th} soil layer, %.
- M = Amount of water added through irrigation during the specified period, mm.
- P0 = Total precipitation received during the growth season, mm.
- K = Change in groundwater during the period, with K = 0.0 being the value used in this study, mm.

3- Water use efficiency (WUE):

WUE calculated using Equation (3), by Blum (2009).

$$WUE = Y * ETa^{-1} \text{………} \quad (3)$$

Y = Total dry tuber yield of potato including both commercial and utility production, kg/fed.

ETa = Actual evapotranspiration for the growing season, mm, calculated by Equation (2).

4- Cost-Benefit Analysis**:**

Cost-Benefit analysis is a method used to assess economic viability of employing soil ameliorants. The cost of these soil ameliorants can be calculated using Equation (4) as described by Xu et al. (2014).

$$\mathbf{I\ (EP\ fed^{-1}) = Pa \times Ra} \quad \text{.............................} \quad (4)$$

Where, Pa (EP/kg) = price of various soil ameliorants; Ra is application rate (kg/fed) of these soil ameliorants. For treatments involving a mixture of ameliorants and HA (A2 and A4), the input cost includes the combined cost of both types of ameliorants. Importantly, this cost accounts only for the expenses related to the soil ameliorants themselves and does not consider other expenses like fertilizers, fuel, ect. These additional costs are assumed to be consistent across the control and other ameliorant treatments in the analysis.

5- The output (O): Involves multiplying the yield of both commercial and utility tubers by their respective prices. It can be expressed as follows:

$$O\ (EP/fed) = Pc * Y * Rc + Pu * Y * Ru \quad \text{................} \quad (5)$$

- Y = Total fresh tuber yield, kg/fed.
- Pc = Average price of commercial tubers over a 10-year period, measured in Egyptian pounds per kilogram, 15 EP/kg.
- RC = Proportion of commercial tubers to the total tuber yield.
- Pu = 10-year average price of utility tubers, which is 6 Egyptian pounds per kilogram (6 EP/kg).
- Ru = Proportion of utility tubers to the total tuber yield.

It's important to note that identical costs for soil ameliorants and tuber prices were utilized in the cost-benefit analysis.

6- Benefit (B): An estimated additional return (or loss) for the changes over the control treatment is provided by this Cost-benefit analysis. Benefit (B) is determined using Equation (6)

$$\mathbf{B\ (EP\ fed^{-1}) = O - I} \quad \text{.......................................} \quad (6)$$

B = Difference between the output (O) and Cost-Benefit (I).

Statistical analysis:

An analysis of variance (ANOVA) was conducted using SAS Version 9.3, according to Snedecor and Cohran (1989). Significance tests were performed using the least significant difference (LSD) at three different significance levels: $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$. The results are displayed in tables and figures, presenting the mean values.

RESULTS

Soil bulk density (D_b):

The soil ameliorants and deficit irrigation water regimes did not have a significant impact ($P \leq 0.05$) on soil bulk density, as shown in Table (2). The D_b values were significantly influenced by soil depth ($P \leq 0.001$). Additionally, the soil bulk density values were not significantly affected ($P \leq 0.05$) by the interaction between any two or 3 factors in this study.

Table 2. ANOVA for impact of soil ameliorant treatment, soil depth and deficit irrigation water regimes on bulk density of sandy soil

Factor	DF	D_b
Ameliorant (A)	5	NS
Irrigation water (W)	2	NS
Soil depth (D)	2	***
A × D	10	NS
A × W	10	NS
W × D	4	NS
A × W × D	20	NS

*** indicate significance at the 0.001 probability level. Not significant is denoted as NS.

Soil moisture content:

The Table (3) presents the results of an ANOVA conducted on the soil moisture content under deficit irrigation water using 50, 80 and 100 % CWR. It demonstrates the varied impact of the ameliorant treatment on soil moisture content at different sampling times. Soil depth consistently exhibited an extremely significant impact ($P \leq 0.001$) on soil moisture content. Conversely, the interaction between treatments and soil depths did not produce any notable impact. However, the ameliorant treatment influenced soil moisture values, which are intricately linked to both evaporation and precipitation. The soil ameliorants exhibited a slightly significant effect ($P \leq 0.05$) on soil moisture content after planting when 50 % CWR was applied. However, their impact became highly significant ($P \leq 0.001$) during the later growth season. This phenomenon was attributed to lower precipitation and higher evaporation during the early growth season, followed by moderate rainfall in the later part of the growth season. The soil ameliorant effect was found to be non- significant at 80 and 100 % CWR during some sampling periods due to sufficient water availability before sampling. Significant differences ($P \leq 0.001$) in soil moisture content across various soil depths were consistently observed during all sampling periods, irrespective of the deficit irrigation water regimes. At 70 days after sowing, the vertical variance in soil moisture content (%) is depicted in Fig. (1). Around this time, approximately 70 days after sowing, the potato plants entered the tuber initiation stage, characterized by vigorous growth and increased nutrient and water requirements. The number, size, weight, and yield of potato tubers affected the availability of water and nutrients at this stage (Claassens and Vreugdenhil, 2000). The soil depth of 20 - 40 cm displayed the highest moisture content compared to other soil depths. Within this depth, the A4 treatment consistently produced the highest soil moisture content. Additionally, the variation between the soil ameliorants was most pronounced at this depth, as depicted in Fig. (1). At each of studied deficit irrigation water regimes, the temporal fluctuations of soil water content varied within the soil depth of 10 - 20 cm, as illustrated in Fig. (2). Minimal variations in soil moisture content were observed between the treatments during periods of both heavy rainfall and drought conditions. However, when precipitation levels fell within the intermediate range, the contrast became notably more pronounced, and the positive effect of the soil ameliorant became statistically significant, as shown in Fig. (2).

Table 3. ANOVA for impact of soil ameliorant treatments and soil depth on soil moisture content for collected soil samples at five periods (days after seeding) under deficit irrigation water regimes

		Days after seeding				
Factor	**DF**	**105**	**90**	**70**	**50**	**0**
		50 % CWR				
Ameliorant (A)	5	***	*	*	*	NS
Soil depth (D)	5	***	***	***	***	***
Ameliorant × Soil depth (A × D)	25	NS	NS	NS	NS	NS
		80 % CWR				
Ameliorant	5	*	NS	***	**	**
Soil depth	5	***	***	***	***	***
Ameliorant × Soil depth (A × D)	25	NS	NS	NS	NS	NS
		100 % CWR				
Ameliorant (A)	5	**	NS	NS	*	**
Soil depth (D)	5	***	***	***	***	***
Ameliorant × Soil depth (A × D)	25	NS	NS	NS	NS	NS

Note: *, **, and *** denote significance at the 0.05, 0.01, and 0.001 probability levels, respectively. "NS" indicates non-significance.

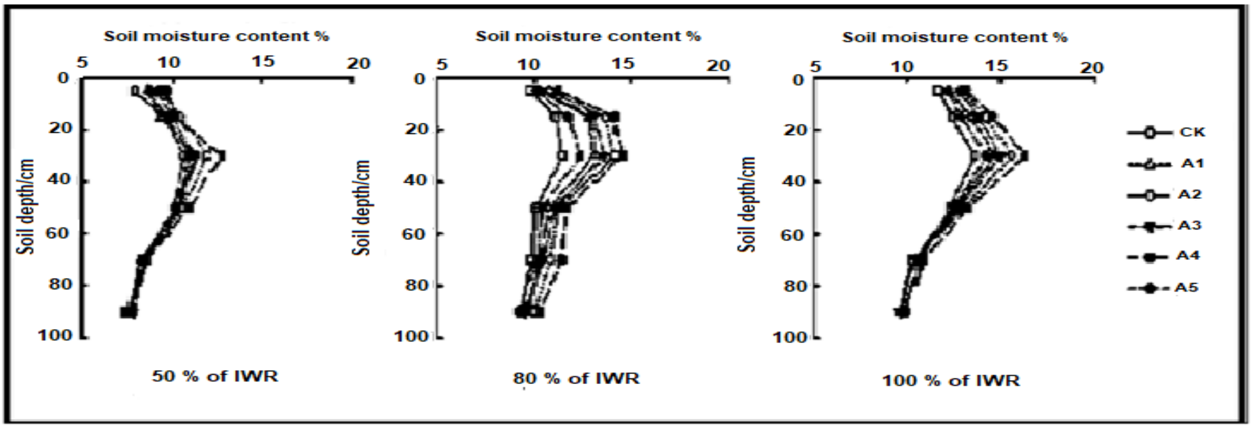

Figure 1. Soil moisture content distribution at 70-d after seeding affected by soil ameliorant treatments and humic acid under deficit irrigation water regimes

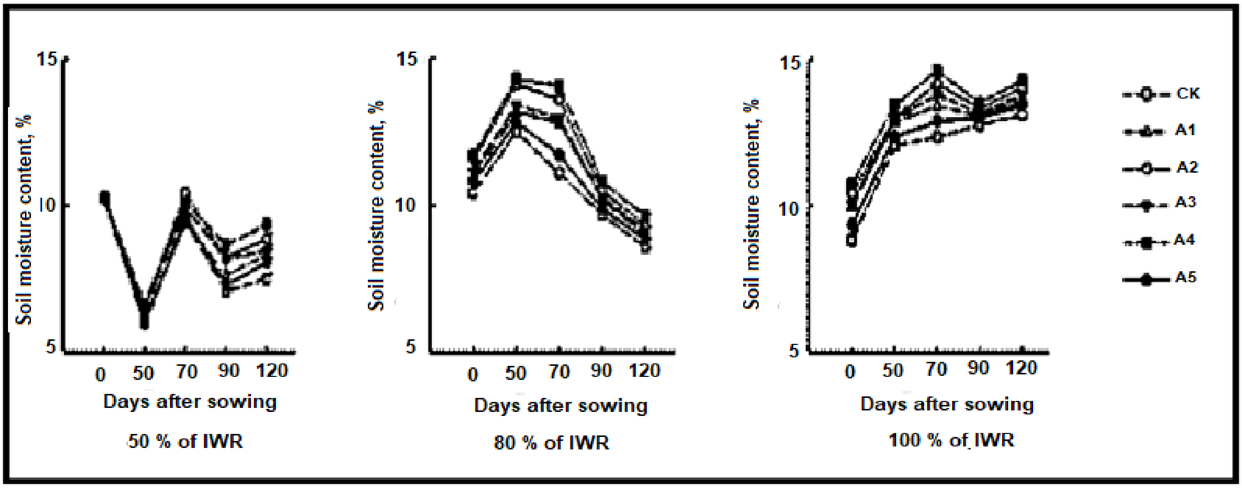

Figure 2.Soil moisture content temporal distribution at soil depth 10 – 20 cm affected by soil ameliorant treatments and humic acid under deficit irrigation water regimes

Soil water storage (SWS):

The soil ameliorants, deficit irrigation water regimes and soil depth had a notably significant impact ($P \leq 0.001$) on soil water storage, Table (4). The interaction between soil ameliorant treatment and soil depth, as well as the interaction between deficit irrigation water regimes and soil depth, showed significant impacts ($P \leq 0.05$) and ($P \leq 0.001$), respectively, on soil water storage Table (4). However, soil water storage was not affected by the interaction between soil ameliorant treatment and deficit water regimes or the interaction between soil ameliorant treatments, deficit irrigation water regimes, and soil depth.

Table 4. ANOVA for effects of soil ameliorant treatment, soil depth and deficit irrigation water regimes on soil water storage, (%) of sandy soil

Factor	DF	SWS
Ameliorant (A)	5	***
Irrigation water (W)	2	***
Soil depth (D)	2	***
A × D	10	*
A × W	10	NS
W × D	4	***
A × W × D	20	NS

*, **, *** indicate significance at the 0.05, 0.01, and 0.001 probability levels, respectively.
Non-significant is denoted as NS.

Figure (3) illustrates the normalized soil water storage concerning the various deficit irrigation regimes of CWR over the days after sowing. Through the normalization process, all soil ameliorant treatments commenced at planting under a deficit irrigation water level of 50 % CWR. Although, absolute variations are hidden, the normalization method allows for observing relative changes among the soil ameliorants in comparison to the control. At harvest time, water storage reached at 1.4 cm under 80 % deficit irrigation water. However, a noticeable decline in soil water storage occurred over the 50 days period after planting with deficit irrigation water set at 50 % CWR, despite the presence of soil ameliorant treatments. The mixed soil ameliorant treatments of A2 (PPA + HA) or A4 (PAM + HA) consistently exhibited the most significant increase in relative soil water storage during each measurement period.

Soil aggregate size fractions

Table (5) presents the results of an analysis of variance (ANOVA) conducted for soil aggregate size fractions under deficit irrigation water regimes of 50, 80, and 100 % CWR. At different aggregate sizes, the soil ameliorant treatments show varying levels of significance in influencing the fractions of soil aggregate sizes. For diameter class ranges both < 0.25 and > 2.0 mm, the soil ameliorants exhibited a highly significant influence ($P \leq 0.01$) on soil aggregate size fractions. However, within the diameter class of 0.25 - 2.00 mm, their impact was not statistically significant ($P \leq 0.05$). All soil aggregate size fractions were consistently and significantly affected by soil depth, displaying a high level of significance ($P \leq 0.001$). However, except for the diametric class range of < 0.125 mm under a deficit irrigation water regime of 50 % CWR, there was slightly significant variation ($P \leq 0.05$) in the interaction between ameliorant treatments and soil depth. Figure (4) illustrates the distribution of

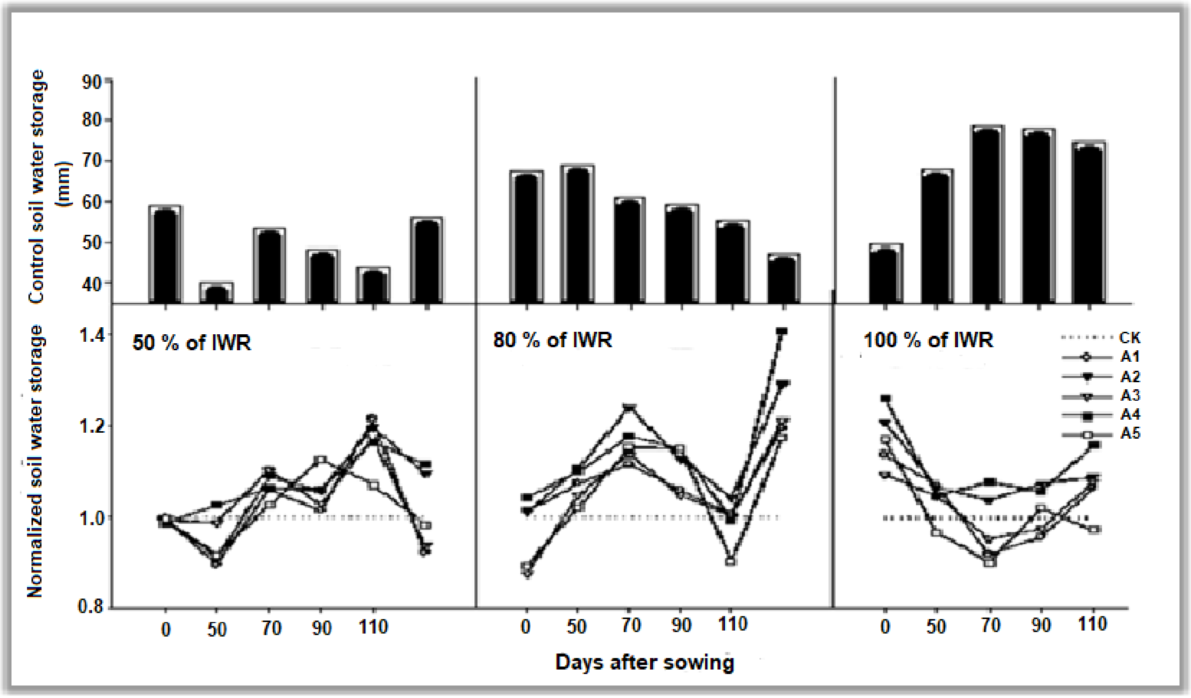

Figure 3. The temporal variation of normalized soil water storage in comparison with control soil water storage affected by soil ameliorant treatments and humic acid under deficit irrigation water regimes

Table 5. ANOVA for impact of the soil ameliorants, soil depth and deficit irrigation water regimes on soil aggregate size fractions

Factors	**DF**	**Soil aggregate size, mm** **> 2**	**1 – 2**	**0.5 – 1**	**0.25 – 0.50**	**0.125 – 0.25**	**< 0.125**
		50 % CWR					
A	5	**	NS	NS	NS	***	***
D	2	**	***	*	***	***	***
A × D	10	NS	NS	NS	NS	NS	*
		80 % CWR					
A	5	***	NS	NS	NS	***	**
D	2	**	***	***	**	***	***
A × D	10	NS	NS	NS	NS	NS	NS
		100 % CWR					
A	5	***	NS	NS	NS	***	***
D	2	***	***	***	***	***	***
A × D	10	NS	NS	NS	NS	NS	NS

Note: *, **, and *** denote significance at the 0.05, 0.01, and 0.001 probability levels, respectively. "NS" indicates non-significance. Laters A and D refer to soil ameliorant treatment and soil depth, respectively.

soil aggregate size fractions affected by soil ameliorants and humic acid treatments under deficit irrigation water regimes at the studied soil depth of 10 – 20 cm. Soil ameliorants indicated an increase in the mass of large macro-aggregates (> 2.0 mm) and a decrease in the mass of micro-aggregates (< 0.25 mm) across each deficit irrigation water regime.

The vertical variation in soil aggregate percentages for different size fractions with applied soil amendments and humic acid under a deficit irrigation water regime of 80 % CWR at the studied soil depths is demonstrated in Fig. (5). At deficit irrigation water regime 80 %, the results indicated that, the soil aggregates' percentage of the micro-size fraction < 0.25 mm varied for studied depths affected by soil ameliorants and humic acid treatments with soil depths ranked as follows: 0 – 10 cm > 10 – 20 cm > 20 – 40 cm. The soil ameliorants and humic acid treatments at a deficit irrigation water regime 80 % had a high impact on soil aggregates' percentage for the moderately (0.25 – 2.0 mm) and a moderate impacted on the large (> 2.0 mm) size fractions at the studied soil depths, as shown in Fig (5). However, there were no statistically difference between the soil ameliorant treatments in their effects on the moderately and large classes of soil size factions.

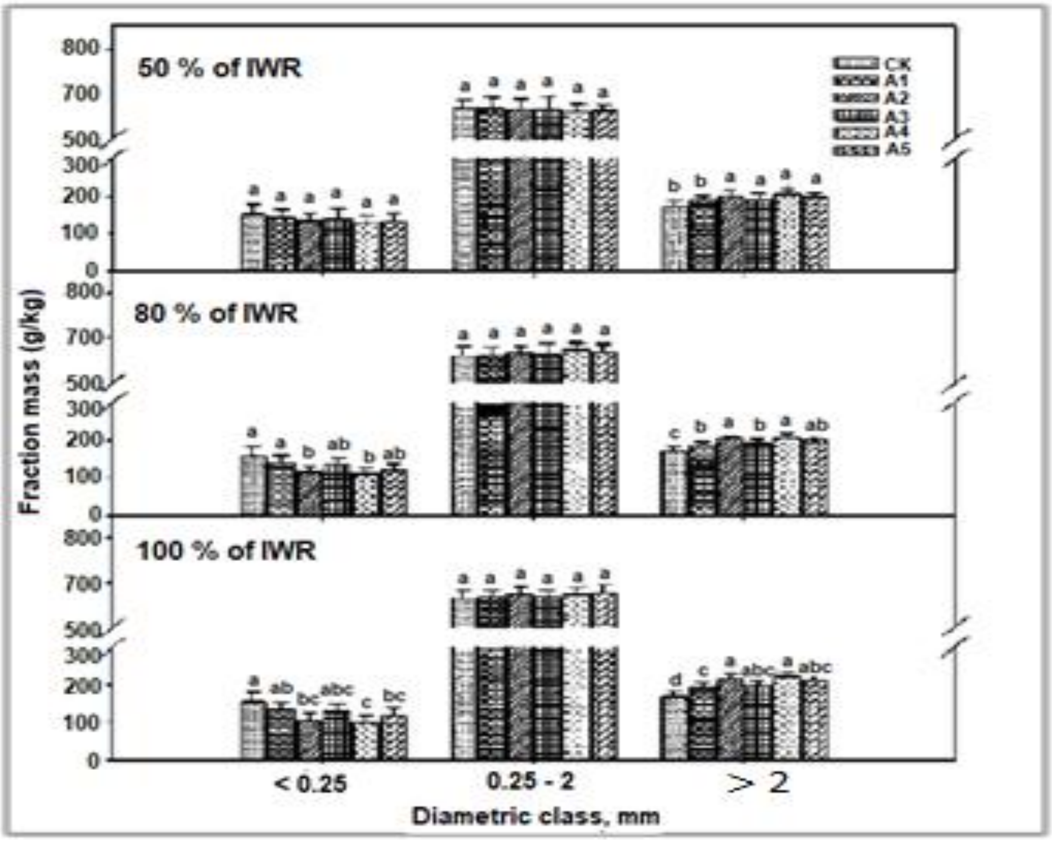

Figure 4. The temporal variation in average percentages of soil aggregates in different mass size fraction affected by soil ameliorant treatments and humic acid at a soil depth of 10 – 20 cm under deficit irrigation water regimes

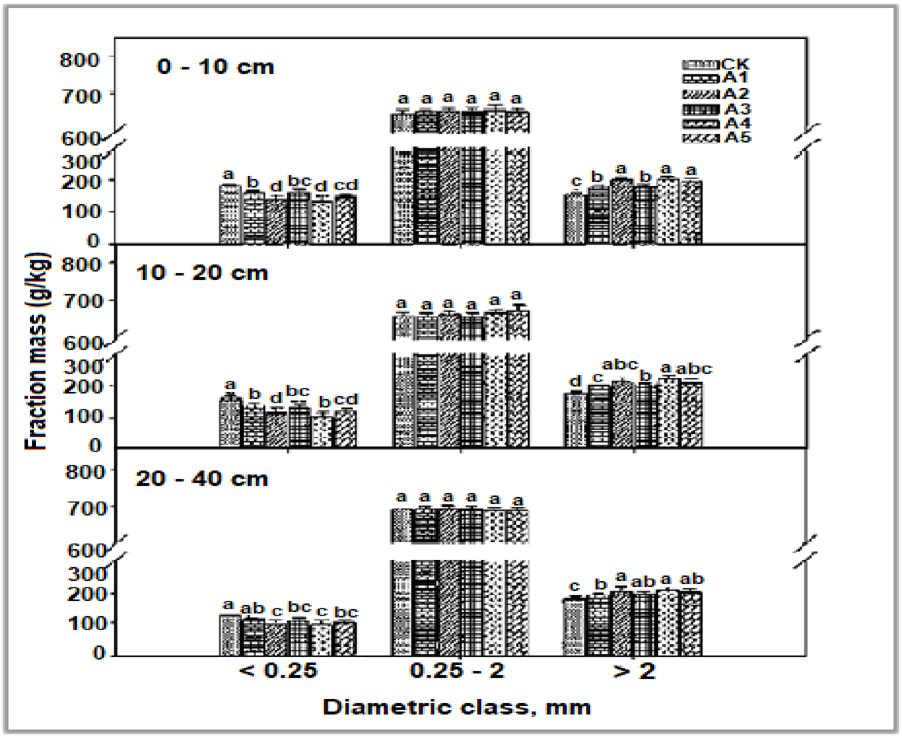

Figure 5. The vertical variation in soil aggregate percentage at different size fraction affected by applied soil amendments and humic acid under deficit irrigation water 80 % CWR for the studied soil depths

Tuber yield, tuber proportion, and tuber size:

The fresh tuber yields significantly increased ($P \leq 0.05$) when amended with all soil ameliorants, compared to the control under the studied deficit irrigation water regimes, as shown in Table (6). At deficit irrigation water regimes (50, 80, and 100 % CWR), soil ameliorant and humic acid treatments enhanced the yield of fresh tubers as percentages ranging from 6.28 – 28.74, 10.34 – 27.09, and 11.74 – 29.35 %, respectively, compared to the CK (control). The mixed treatment of A4 resulted in the greatest yield of fresh tuber, with yields of 22.53, 25.80, and 29.75 tons fed^{-1} at deficit irrigation water regimes of 50, 80, and 100 % CWR, respectively. The tubers were categorized into three groups based on their weight: >150 (commercial tuber), 75-150 g and < 75 g (utility tuber). These categories were denoted as 1, 2, and 3, respectively.

Table (6) displays the different proportions by weight of tubers in each category. Soil ameliorants resulted in an increase in the percentage of tubers in category 1 by 1.8 - 11.1, 3.1 - 17.5 and 3.9 - 14.8 % under deficit irrigation water regimes of 50, 80 and 100 % CWR, respectively. However, the increase in percentage of tubers in category 2 decreased more compared to category 1, ranging from 1.0 - 5.0, 0.4 - 1.9 and 0.1 - 1.6 % at 50, 80 and 100 % CWR, respectively. In contrast, the percentage of tubers in category 3 (utility tuber) significantly decreased more than category 2, showing a decrease of 16.3 - 4.0, 19.3 - 5.1 and 16.3 - 4.3 % at deficit irrigation water regimes of 50, 80 and 100 % CWR, respectively, compared to the control. The mixed treatment of A4 (PAM + HA) consistently resulted in the highest proportion of commercial tubers (category 1), accounting for 56.3, 67.8 and 78.4% under deficit irrigation water regimes of 50, 80, and 100% CWR, respectively. The observed effect was statistically significant ($P \leq 0.05$) at the studied deficit irrigation water regimes.

However, for each of the deficit irrigation water regimes, soil ameliorants did not have a significant impact ($P \leq 0.05$) on category 2 and showed no effect on category 3. Both fresh tuber yield and commercial yield exhibited a consistent pattern, with the sequence ranked in descending order as follows: A4 > A2 > A3 > A1 > A5 > CK treatments. The mixed soil ameliorants with humic acid treatment of A4 and A2 often yielded more fresh tubers compared to studied soil ameliorants or humic acid individually (A1, A3, and A5). However, the difference in yield was not consistently significant, as shown in Table (6).

Table 6. Fresh tuber yield and the proportion of tubers in various size categories affected by soil ameliorants and humic acid treatments at deficit irrigation water regimes of 50, 80 and 100 % CWR

Treatments	Fresh tuber yield ton/fed	Yield increasing %	Tuber proportion, %		
			Commercial Category 1	Category 2	utility tuber Category 3
			> 150 g	75 – 150g	< 75g
50 % CWR					
CK	17.50 (0.6) d	-	45.2 (4.2) b	21.8 (1.1) a	32.9 (5.2) a
A1	19.43 (1.1) bc	11.03	49.7 (3.1) ab	22.8 (1.3) a	27.5 (2.8) ab
A2	21.25 (1.1) ab	21.43	52.4 (3.6) ab	24.9 (2.4) a	22.7 (5.9) ab
A3	20.45 (0.9) bc	16.86	51.0 (4.7) ab	23.4 (1.2) a	25.4 (5.3) ab
A4	22.53 (1.5) a	28.74	56.3 (5.6) a	26.8 (0.7) a	16.6 (5.3) b
A5	18.60 (0.7) cd	6.28	47.0 (3.3) b	23.1 (1.5) a	28.9 (4.1) ab
80 % CWR					
CK	20.30 (0.6) c	-	50.3 (1.8) d	11.1 (1.8) a	38.6 (2.1) a
A1	22.85 (1.2) bc	12.56	59.0 (3.4) bc	11.5 (1.8) a	29.5 (4.0) ab
A2	24.74 (1.7) b	21.87	64.0 (0.3) ab	12.2 (1.5) a	23.8 (1.6) bc
A3	23.92 (1.6) b	17.83	61.9 (5.0) ab	11.8 (1.1) a	26.4 (4.0) bc
A4	25.80 (1.8) a	27.09	67.8 (5.1) a	12.9 (1.7) a	19.3 (6.2) c
A5	22.40 (1.0) bc	10.34	53.4 (1.8) cd	13.0 (1.6) a	33.5 (0.9) ab
100 % CWR					
CK	23.00 (2.4) b	-	63.6 (2.6) d	10.5 (2.2) a	25.8 (3.8) a
A1	26.32 (2.6) a	14.43	70.5 (0.4) bc	11.7 (0.8) a	17.8 (1.2) abc
A2	28.71 (2.8) a	24.82	76.1 (2.7) ab	11.2 (1.5) a	12.7 (1.2) bc
A3	27.00 (2.6) a	17.39	74.5 (2.2) ab	10.6 (0.4) a	14.9 (1.8) bc
A4	29.75 (3.1) a	29.35	78.4 (2.3) a	12.1 (0.7) a	9.5 (1.7) c
A5	25.70 (2.5) ab	11.74	67.5 (6.9) cd	11.0 (0.6) a	21.5 (6.4) ab

Note: The letters 'a', 'b', and 'c' denote significant differences at a probability level of $P \leq 0.05$ according to protected LSD test. The numbers provided in brackets represent the standard deviation.

Water use efficiency (WUE)

The application of soil ameliorants resulted in an improvement in water use efficiency (WUE) ranging from 4.18 to 34.9 % (Fig. 6). The greatest WUE was noted for soil ameliorants and humic acid treatments at a deficit irrigation regime of 80 % CWR. Additionally, the A4 treatment demonstrated the highest WUE (31.4 kg/fed/mm) at 80 % CWR. Notably, there were no significant distinctions ($P \leq 0.05$) among the five treatments of soil ameliorants and humic acid at 100 % CWR. However, the WUE for all five ameliorant treatments was significantly higher ($P \leq 0.05$) compared to the WUE for the CK treatment, which stood at 15.6 kg/fed/mm. In comparison to the CK treatment, the WUE increased by 20.87 - 38.94% with soil ameliorants at 100 % application of CWR (Figure 6). The WUE consistently showed higher values for mixed ameliorant treatments compared to single ameliorant treatments across all three deficit irrigation water regimes. However, these differences were not statistically significant ($P \leq 0.05$).

Cost Benefit Analysis

Among the studied deficit irrigation water regimes, only A1 and A3 treatments showcased consistent increases in economic returns. When employing the A1 and A3 treatments at a deficit irrigation water regime of 50% CWR, the returns exhibited an increase of 7830 and 13725 EP/fed, respectively, compared to the CK (Control), as depicted in Table (7). At an applied deficit irrigation water regime of 80% CWR, the returns surpassed those attained at a 50% CWR. Consequently, among the five ameliorant treatments, the two treatments, A1 and A3, produced favorable outcomes. The treatment A3 recorded the highest economic return when applying a deficit irrigation water regime of 80%, showing an increase of 17745 EP/fed compared to the CK (Control). In the case of a full irrigation water regime of 100% CWR, both A1 and A3 ameliorants resulted in a positive economic return. However, it was observed that the A3 treatment provided the greatest economic return, with a notable increase of 20025 EP/fed compared to both the CK and the other treatments.

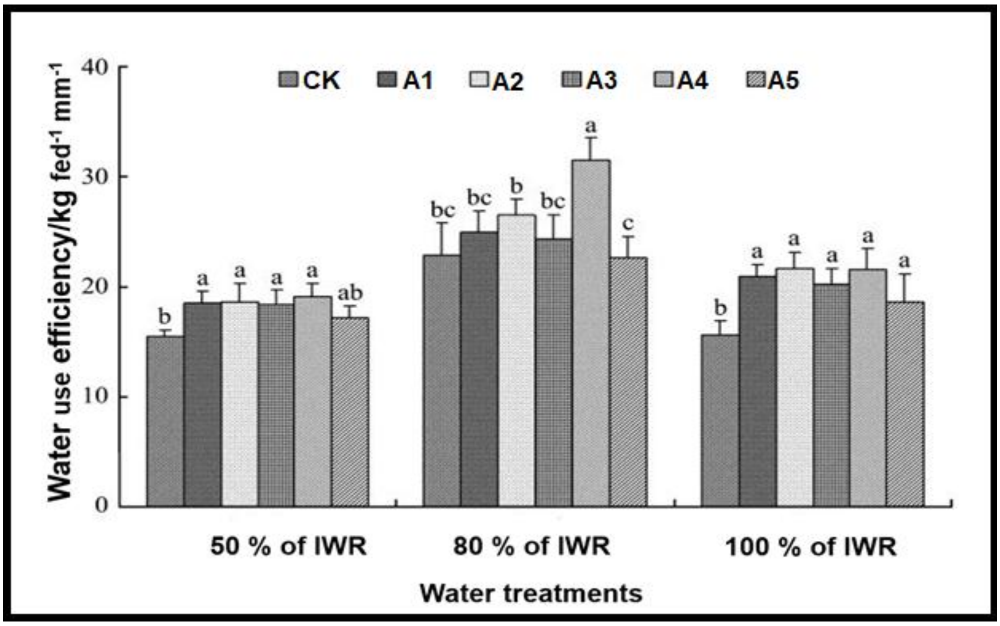

Figure 6. Water use efficiency of dry potato tubers with soil ameliorants and humic acid under the studied deficit irrigation water regimes. Bars sharing the same letters indicate no significant differences at P = 0.05 according to a protected LSD test

Table 7. Cost benefit of using soil ameliorants and humic acid on potatoes under deficit irrigation water levels (EP/fed) compare to the control

Ameliorant Treatment	Input (EP/fed) (Price of ameliorants)	Fresh tuber yield, Ton/fed	Output, EP/fed (6 EP/Kg tuber)	Increase in output as benefit, EP/fed
		100 % of CWR		
CK	-	23.00	138000	-
A1	3750	26.32	157920	16170
A2	43750	28.71	172260	-9490
A3	3975	27.00	162000	20025
A4	43975	29.75	178500	-3475
A5	40000	25.70	154200	-23800
		80 % of CWR		
CK	-	20.30	121800	-
A1	3750	22.85	137100	11550
A2	43750	24.74	148440	-17110
A3	3975	23.92	143520	17745
A4	43975	25.80	154800	-10975
A5	40000	22.40	134400	-27400
		50 % of CWR		
CK	-	17.50	105000	-
A1	3750	19.43	116580	7830
A2	43750	21.25	127500	-21250
A3	3975	20.45	122700	13725
A4	43975	22.53	135180	-13795
A5	40000	18.60	111600	-33400

When analyzing the cost-benefit across studied deficit irrigation water regimes, it was observed that single ameliorant treatments yielded a superior economic return compared to mixed ameliorant treatments. However, the T5 treatment did not enhance the economic return, primarily due to its elevated input costs. When the economic returns from water management, rationalized through irrigation amount, were combined with the returns resulting from ameliorants, no overall increase in economic returns was observed across all ameliorant treatments when applying 100% CWR, as this method completely fulfills plant water requirements. In contrast, the decrease in economic returns was less pronounced in the A1 and A3 treatments compared to both the CK and the other three ameliorants, as indicated in Table (8). When factoring in rationalized irrigation water returns, the economic returns in the 80% CWR treatment were lower than those in the 50% CWR treatment. Among the five treatments, it was noted that both A1 and A3 produced positive outcomes, with A3 achieving the highest economic return, showing an increase of 22145 EP/fed compared to the CK, as indicated in Table 8. However, it was observed that using 80% CWR application proves to be the most cost-effective option in terms of both costs and profitability. This method allows for potato production levels close to that of the 100% CWR treatment. This observation holds significance, especially considering that the cost of irrigation water is typically not factored into the total expenses in Egypt. In the face of water scarcity, implementing a 50% CWR treatment becomes a viable approach to achieve moderate potato production.

Table 8. Cost benefit of using soil ameliorants plus rationalized irrigation water under studied deficit irrigation water regimes (EP/fed) in comparison to the control

Deficit irrigation water regimes	Amount of consumed irrigation water (m^3/fed)	Amount of rationalized water (m^3/fed)	Price average per cubic meter of water (EP/m^3)	Total price of rationalized irrigation water (EP/fed)	Total benefit of output from ameliorant + rationalized IW, (EP/fed)
100 %					
CK	**2200**	**0**	**10**	**0**	**-**
A1					**16170**
A2					**-9490**
A3					**20025**
A4					**-3475**
A5					**-23800**
80 %					
CK	**1760**	**440**	**10**	**4400**	**-**
A1					**15950**
A2					**-12710**
A3					**22145**
A4					**-6575**
A5					**-23000**
50 %					
CK	**1100**	**1100**	**10**	**11000**	**-**
A1					**18830**
A2					**-10250**
A3					**24725**
A4					**-2795**
A5					**-22400**

DISCUSSION

The data indicate that soil moisture content within the 0-40 cm depth was notably influenced by soil ameliorants compared to the control treatment. However, limited impact was observed within the 0-10 cm depth, likely due to water loss through evapotranspiration (Fig. 1). Across all soil depths, a consistent trend in soil moisture content was noted with the application of soil ameliorants, with mixed ameliorants demonstrating a more substantial effect compared to single soil ameliorants under studied deficit irrigation regimes. Our expected that more than 40 cm depth, variations between soil ameliorant treatments were less pronounced compared to the surface depths (< 40 cm). The ameliorant treatments are introduced into the surface depths of the soil through tillage and do not extend into deeper depths. These treatments resulted in increased temporal fluctuations of soil moisture content at depths up to 100 cm, particularly under deficit irrigation water regimes of 80% CWR. The effect was also noticeable, albeit to a lesser extent, when 50% and 100% CWR were employed (Fig. 2). This suggests that soil ameliorants, introduced into the soil to a depth of 20 cm through tillage, have the capacity to influence soil moisture content at deeper depths. Soil ameliorant treatments have shown a significant impact on soil water storage, particularly in regions prone to frequent droughts or where irrigation is sporadic (Fig. 3). They effectively conserve limited irrigation water, reduce evaporation losses, and increase the available water for crop growth (Agaba et al., 2010; Al-Humaid and Moftah, 2007; Wu et al., 2008). Consequently, under conditions of deficit irrigation water at 80% CWR, these ameliorant treatments could play a crucial role in sustaining crop production in semi-arid regions. In this experiment, soil ameliorant treatments did not exhibit a statistically significant impact ($P \leq 0.05$) on soil bulk density (Table 2). In contrast, Abel et al. (2013) and Hussien et al. (2012) reported that soil ameliorants effectively decreased soil bulk density. It's plausible that the soil ameliorants led to a slight decrease in soil bulk density in the short term, although this impact did not reach statistical significance. Further, research conducted over an extended period is necessary to determine whether water-adsorbing soil ameliorants indeed exert a substantial influence on soil bulk density. Soil ameliorants had a notably significant impact ($P \leq 0.01$) on soil aggregate size fractions in both small and large diameter classes (Table 5). These ameliorants resulted in an increase in the mass of larger macro-aggregates (> 2.0 mm) and a reduction in the mass of micro-aggregates (< 0.25 mm) at studied soil depths under deficit irrigation water regimes of 50%, 80%, and 100% CWR (Fig. 4 and 5). This outcome aligns with the findings of Materechera (2009).

Generally, soils containing a higher proportion of larger macro-aggregates tend to exhibit greater structural stability and enhanced water and nutrient retention, as confirmed by Angers (1992). Such soil conditions contribute to improved circumstances for crop growth. Moreover, some researchers have emphasized the critical role of soil aggregation in various soil processes, encompassing physical, chemical, and biological aspects, as noted by Márquez et al. (2004) and

Tang et al. (2011). The role of soil aggregation in agriculture is crucial for crop production, as emphasized by Bronick and Lal (2005). Additionally, there is a strong and positive correlation between soil aggregation and hydrophilic humic acid and polymers, as indicated by Liu et al. (2009). Enhanced and stable soil aggregation offers advantages for both crop growth and the mitigation of soil erosion, in line with insights provided by Sojka et al. (2007). The application of soil ameliorants at deficit irrigation water regimes of 50%, 80%, and 100% CWR resulted in increased potato fresh tuber yield, commercial tuber proportion, and water use efficiency (WUE), as highlighted in Table (6) and Fig. (6). These results align with those reported by Dorraji et al. (2010) for corn. Economic returns are significantly influenced by both the total yield and the proportion of commercial tubers, given that commercial tubers are valued at more than twice the rate of utility tubers.

The utilization of soil ameliorants led to higher potato fresh tuber yields, an increased proportion of commercial tubers, and improved water use efficiency (WUE). The A4 treatment consistently resulted in the highest fresh tuber yield, commercial tuber proportion, water use efficiency (WUE), and crop value. However, despite its significant benefits, it did not yield a profitable return in any of the three water treatments due to its high expense. Among the ameliorant treatments, A1 and A3 showed greater economic returns compared to the mixed amendment treatments (A2 and A4). However, the economic return for the single ameliorant treatment (A5) did not observe. The data on soil moisture content, fresh tuber yield, and water use efficiency (WUE) suggest that mixed ameliorant treatments outperform single ameliorant treatments. This implies that increasing the dosage of a single ameliorant treatment could potentially yield results similar to those of mixed ameliorant treatments. Synthetic polymers showed favorable compatibility with the natural soil ameliorant HA, resulting in positive impacts on plant growth, enhancing both yield and water use efficiency (WUE). These findings align with those from Huang et al. (2007).

CONCLUSION

In this research, we investigated the comparative impact of various soil ameliorants on different aspects of potato production in a semi-arid region, El-Qantara Shark, focusing on their effects on soil physical characteristics, fresh tuber yield, tuber size, commercial tuber proportion, water use efficiency (WUE), and the economic returns associated with potato production. The soil ameliorants showed a significant impact (≤ 0.05) on soil moisture content, particularly notable in the soil depth of 20 - 40 cm. Furthermore, these ameliorants significantly influenced (≤ 0.05) the distribution of soil aggregate sizes at specific soil depths. The application of soil ameliorants resulted in improved soil conditions for potato growth, leading to increased fresh tuber yield, a higher proportion of commercially viable tubers, and enhanced water use efficiency (WUE). Nevertheless, the use of PAM alone consistently yielded the most substantial improvement in economic returns under deficit irrigation water treatments. This highlights the opportunity to enhance both soil physical characteristics and the environmental sustainability of potato production in semi-arid regions through the integration of water-adsorbing soil ameliorants. It's crucial to consider yield disparities and input costs when determining the most profitable system for farmers. The widespread adoption of ameliorant usage is expected to drive advancements in manufacturing technology. As demand increases, leading to economies of scale, production costs for ameliorants are likely to decrease, bolstering economic prospects for farmers. Clearly, further efforts are necessary to fine-tune the application rate of ameliorants to maximize benefits and economic returns. A deeper understanding of this subject will form the basis for crafting management strategies aimed at improving soil water utilization in crop production within semi-arid regions

REFERENCES

Abel, G., A. Peters, S. Trinks, H. Schonsky, M. Facklam and G. Wessolek. 2013. Impact of biochar and hydro-char addition on water retention and water re-pellency of sandy soil. Geoderma. 202–203:183–191.

Agaba, H., L. J. BagumaOrikiriza, J. F. OsotoEsegu, J. Obua, J. D. Kabasa and A. Hüttermann. 2010. Effects of hydrogel amendment to different soils on plant available water and survival of trees under drought conditions. Clean Soil, Air, Water. 38(4): 328 -335.

Al-Humaid, A., and A.E. Moftah. 2007. Effects of hydrophilic polymer on the survival of button wood seedlings grown under drought stress. Journal of Plant Nutrition. 30: 53–66.

Angers, D.A. 1992. Changes in soil aggregation and organic carbon under corn and alfalfa. Soil Science Society of American Journal. 56:1244–1249.

Archibold, O.W. 1995. Ecology of world vegetation. Chapman & Hall Ltd, London, UK.

ASTM. 2014. Standard test methods for moisture, ash, and organic matter of peat and other organic soils. West Conshohocken, PA: ASTM International https://doi.org/10.1520/ D2974. 07A.2.

Bhardwaj, A. K., I. Shainberg, D. Goldstein, D.N. Warrington and G.J. Levy. 2007. Water retention and hydraulic conductivity of cross-linked poly acrylamides in sandy soils. Soil Science Society of American. Journal. 71:406–412.

Biro, K., B. Pradhan, M. Buchroithner and F. Makeschin. 2013. Land use/land cover change analysis and its impact on soil properties in the northern part of Gadarif region. Sudan. Land Degrade Development. 24: 90–102.

Blaney, H. F. and W. D. Criddle. 1962. Determining consumptive use and irrigation water requirements. USDA Technical Bluletin 1275. US Depart. Agric. Beltsville., 59.

Blum, A. 2009. Effective use of water (EUW) and not water-use efficiency (WUE) is the target of crop yield improvement under drought stress. Field Crop Research, 112(2-3): 119-123.

Bronick, C.J. and R. Lal. 2005. Soil structure and management: A review. Geoderma, 124(1-2):3-22.

Chapman, H.D. and P.F. Pratt. 1978. Methods of Analysis for Soils. Plants and Water. University of California, Prical Publication, Vol. 4030: 12 – 19.

Chu, P. F., D. Wang, Y. L. Zhang, X. Y. Wang, X. Z. Wang and Z. W. Yu. 2009. Effects of irrigation stage and amount on water consumption characteristics, grain yield and content of protein components of wheat. Scientia Agricultura Sinica. 42(4): 1306 -1315.

Claassens, M. M. J. and D. Vreugdenhil. 2000. Is dormancy breaking of potato tubers the reverse of tuber initiation? Potato Research, 43(4): 347-369.

Debaeke, P. and A. Aboudrare. 2004. Adaptation of crop management to water-limited environments. European Journal of Agronomy. 21(4): 433-446.

Dorraji, S. S., A. Golchin and S. Ahmadi. 2010.The Effects of Hydrophilic Polymer and Soil Salinity on Corn Growth in Sandy and Loamy Soils. Clean Soil Air Water. 38(7): 584-591.

Easterling, W. E. 2007. Climate change and the adequacy of food and timber in the 21st century. Proceedings of the National Academy of Sciences, USA. 104(50): 19-79.

El-Naggar, A.H. and N.M. Esmaiel. 2022. Evaluation the Effect of Humic Acid and Some Soil Amendments on Rooting and Growth of Dracaena marginata Cuttings. Alexandria Science Exchange Journal, 43(4), pp.703-710.

Falkenmark, M. and J. Rockström. 2004. Balancing water for humans and nature: the new approach in eco-hydrology. Earthscan, London, UK.

FAO. 1985. Water quality guidelines for agriculture, surface irrigation and drainage. Vol. 1. Food and Agriculture Organization. 29 pp.

Hayat, R. and S. Ali. 2004. Water absorption by synthetic polymer (aquasorb) and its effect on soil properties and tomato yield. International Journal of Agriculture and Biology. 6: 998–1002.

Holliman, P. J., J. A. Clark, J. C. Williamson and D. L. Jones. 2005. Model and field studies of the degradation of cross-linked polyacrylamide gels used during the re-vegetation of slate waste. Science of the Total Environment. 336(1-3): 13-24.

Huang, Z. B., L. C .Zhang, L. Dong, J. Y. Zhou and H. Huang. 2007. Study on properties of different kinds of water retentive agents and effects on growth of maize. Journal of Soil and Water Conservation. 21(1): 140-143.

Hussien, R.A., A.M. Donia, A.A. Atia, O.F. El-Sedfy, A.R.A. El-Hamid. and R.T. Rashad. 2012. Studying some hydro-physical properties of two soils amended with kaolinite-modified cross-linked poly-acrylamides. Catena. 92:172–178.

Hüttermann, A., L.J.B. Orikiriza and H. Agaba. 2009. Application of super- absorbent polymers for improving the ecological chemistry of degraded or polluted lands. CLEAN Soil Air Water 37:517–526.

Islam, M. R., S. Xue, C. Mao, A. Ren, E. Eneji and Y. G. Hu. 2011. Effects of water-saving superabsorbent polymer on antioxidant enzyme activities and lipid peroxidation in oat (*Avena sativa* L.) under drought stress. Journal of the Science of Food and Agriculture. 91(4): 680-686.

Liu, J., B. Shi, H.T. Jiang, S. Bae and H. Huang. 2009. Improvement of water-stability of clay aggregates admixed with aqueous polymer soil stabilizers. Catena. 77: 175–179.

LiYQ, H., T. L.Awada, X. H. Zhou, W. Shang, Y. P. Chen and X. A. Zuo.2012. Mongolian pine plantations enhance soil physio-chemical properties and carbon and nitrogen capacities in semi-arid degraded sandy land in China. Applied Soil Ecology. 56:1–9.

Mann, K. K., A. W. Schumann, T. A.Obreza, J. B. Sartain, W. G. Harris and S. Shukla. 2011. Analyzing the efficiency of soil amendments and irrigation for plant production on heterogeneous sandy soils under greenhouse conditions. Journal of Plant Nutrition and Soil Science. 174(6): 925-932.

Márquez, C. O., V. J. Garcia, C. A. Cambardella, R. C. Schultz and T. M. Isenhart. 2004. Aggregate-size stability distribution and soil stability. Soil Science. Society of American Journal. 68: 725–735.

Materechera, S. A. 2009. Aggregation in a surface layer of a hard setting and crusting soil as influenced by the application of amendments and grass mulch in a South African semi-arid environment. Soil and Tillage Research. 105:251–259.

Mohsen, S. P., R.Majid and G. K. Borzo. 2009. Prediction of Soil Exchangeable Sodium percentage based on Soil Sodium Adsorption Ratio. American-Eurasian, Journal of Agricultural and Environmental Sciences. 5(1): 01-04.

Qin, S. H., J. L. Zhang, H. L. Dai, D. Wang and D. M. Li. 2014. Effect of ridge– furrow and plastic-mulching planting patterns on yield formation and water movement of potato in a semi-arid area. Agricultural Water Management. 131:87–94.

Rivero, R. M., M. Kojima, A. Gepstein, H. Sakakibara, R. Mittler, S. Gepstein and E. Blumwald. 2007. Delayed leaf senescence induces extreme drought tolerance in a flowering plant. Proceedings of the National Academy of Sciences of the United States of America USA. 104 (49): 19631-19636.

Seilsepour, M., M. Rashidi, and B.G. Khabbaz. 2009. Prediction of soil exchangeable sodium percentage based on soil sodium adsorption ratio. American-Eurasian Journal of Agricultural and Environmental Sciences, 5(1), pp.1-4.

Sepaskhah, A. R. and A. R. Bazrafshan-Jahromi. 2006. Controlling runoff and erosion in sloping land with polyacrylamide under a rainfall simulator. Biosystem Engineering. 93(4): 469-474.

Snedecor, G.W. and W. G. Cohran. 1989. Statistical Method" 6th ed., Iowa State Univ. Press, Amess, Iowa, USA., p. 593.

Sojka, R. E., D. L. Bjorneberg, J. A. Entry, R. D. Lentz and W. J. Orts. 2007. Polyacrylamide in agriculture and environmental land management. Advances in Agronomy. 92: 75–162.

Spooner, D. M. and J.B. Bamberg. 1994. Potato genetic resources: sources of resistance and systematics. American Journal of Potato Research. 71:325–338.

Tang, J., Y. H. Mo, J. Y. Zhang and R. D. Zhang. 2011. Influence of biological aggregating agents associated with microbial population on soil aggregate stability. Applied Soil Ecology. 47: 153–159.

Trenkel, M. E. 1997. Controlled-release and stabilized fertilizers in agriculture. International Fertilizer Industry Association, Paris, France.

Turan, M. A., B. B. AȘIK, A. V. Katkat and H.Celik. 2011. The effects of soil-applied humic substances to the dry weight and mineral nutrient uptake of maize plants under soil-salinity conditions. Notulae Botanicae Horti Agrobotanici Cluj-Napoca. 39 (1): 171-177.

Wu, L., M. Z. Liu and R. Liang. 2008. Preparation and properties of a double-coated slow release NPK compound fertilizer with super absorbent and water-retention. Bioresource Technology. 99: 547–554.

Xu, S., L. Zhang, N. B. McLaughlin, J. Mi, Q. Chen and J. Liu. 2014. Evaluation of synthetic and natural absorbing soil amendments for potato production in a semi-arid region. Agricultural Engineering International: CIGR Journal. 16 (4): 24–34.

Zhang, M. K ., Z. L. He, D. V. Calvert, P. J. Stoffella, X. E. Yang and Y. C. Li. 2003. Phosphors and heavy metal attachment and release in sandy soil aggregate fractions. Soil Science Society of American Journal. 67:1158–1167.

الملخص العربي

تأثير المحسنات الدامصة على بعض الخصائص الفيزيائية وإنتاجية البطاطس في التربة الرملية تحت ظروف نقص مياه الري

سحرمحمد إسماعيل و صلاح عبد النبي القوسي

تتميز الأراضى الرملية بتخزين مائي منخفض وخصوبة ضعيفة. تمت هذه الدراسة في منطقة قناة السويس لتحسين وتقييم بعض الخصائص الفيزيائية للتربة ومكونات إنتاجية البطاطس والجودة والعوائد الاقتصادية كنتيجة لإضافة محسنات تربة دامصة (PPA) و(PAM) وحمض الهيوميك (HA)وخليط كل منها مع الآخر بالإضافة إلى الكنترول تحت ظروف نقص مياه الرى المياه ١٠٠ و٨٠ و٥٠ ٪ من الإحتياجات المائية للمحصول (CWR) مع ثلاث مكررات. أظهرت النتائج أن المعاملة المختلطة للمحسن PAM مع حمض الهيوميك أعطى أعلى محتوى رطوبى للتربة عند عمق ٢٠–٤٠ سم من التربة. استطاعت المحسنات الأرضية تحسين تخزين المياه في التربة وتوزيع حجم تكتلات التربة بشكل ($P \leq 0.01$) أفضل. أظهرت النتائج أيضا أنه تحت ظروف نقص مياه الرى أدى إضافة المحسنات الأرضية إلى زيادة نسبة كتلة الحبيبات الكبيرة للتربة (> ٢ مم) وكتلة الحبيبات الدقيقة للتربة(<٠,٢٥ مم) في جميع أعماق التربة. المعاملة المختلطة لـ حمض الهيوميك + PAM أنتج أعلى إنتاج طازج للبطاطس ونسبة أعلى من البطاطس التجارية. كانت قيم كفاءة استخدام المياه (WUE) أعلى مع المحسنات المختلطة مقارنة بالمحسنات الفردية تحت ظروف نقص مياه الري. وجد أن استخدامات PPA أو PAM وحدها لديها عائد اقتصادي أعلى من المحسنات المختلطة ولم يتم الكشف عن العائد الاقتصادي عند استخدام حمض الهيوميك بمفرده.