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The Impact of Compost and Polymers Applications on Potato Plants under Water Stress Conditions:

1- Vegetative Growth and Water Relationships

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ABSTRACT

A field experiment was performed using potato (*Solanum tuberosum* L.; cv. Cara) grown in a private farm at Meet Zonkor village, Talkha, Dakahlia Governorate, to test the influence of water quantities, compost and polymer on growth of potato plants and water relationships under drip irrigation method in 2016 and 2017 summer growing seasons. A strip-split plot design was used with irrigation water quantities (800 "draught stress", 1200 and 1600 m^3/fed) and the last water quantity is considered as the common water management (control treatment) as main plots, compost (0 and 7.5 ton/fed) and polymer matrix composite (PMC) at the rates of (0, 10, 20, 30 kg/fed) as soil conditioners randomly distributed within sub and strip-plots, respectively. Each treatment was repeated three times. Application of compost or polymer significantly affects the vegetative growth and its water relationships issues compared to control. The mutual interaction of irrigation with 1200 or 1600 m^3/fed with compost soil amendments (7.5 ton/fed) and polymer (30 kg/fed) had significant effects on most vegetative growth features (plant height, dry weight and leaves area) of potato plants. Moreover, data showed that plant water relationships parameters (relative transpiration rate, RTR and leaf water deficient, LWD) were significantly affected with the highest levels of irrigation water quantity without application of soil conditioners (compost and polymer) in both seasons. Furthermore, including polymer dually with compost under the scarce of water irrigation led to better water use efficiency WUE.

Keywords: Potato, irrigation regimes, water quantities, compost, polymer, growth characters, plant water relationships, water use efficiency, WUE.

INTRODUCTION

Water is a critical and vital factor for growth, yield and quality of crops; potato (*Solanum tuberosum* L.) is very sensitive to water stress (Hang and Miller, 1986; Nadler and Heuer, 1995). Irrigation water is one of the neutral resources which is receiving close attention at the present time especially after the shortage of water resources and increasing population. In case of potato plants, the requirement for water during the growth period ranges between 500–700 mm (Brower and Heibloem, 1986). This quantity of water is influenced by soil conditions, the variety, and time of maturity (early/late ripening). Drought during the growing seasons negatively affects potato growth and tuber yields. Jerez *et al.* (1991) found that water stress abridged plant height and dry weight of whole plant of potato crop. Shehata and Abo-Sedera (1994) showed that, irrigated potatoes with an interval of ten led to increasing in plant height and foliage fresh weight. Gameh *et al.* (2000) indicated that water regime at 60 min/day under drip irrigation system recorded the highest foliage weight of potatoes in both cultivars of Draga and Diamant overcame 30 min/day regime. The increasing of the amount of irrigation water resulted in significant increases of plant height, foliage fresh and dry weights per plant of potato (El-Banna *et al.*, 2001).

Indira and Kabeerathumma (1990) reported that transpiration rate in sweet potato leaves decreased with decreasing soil moisture content. Hammad (1991) indicated that the percentage of both free and total water in snap bean leaves were increased as the amount of water supply to the soil increased, while the bound water was increased as irrigation levels decreased. These results are also quite consistent with those obtained by Gawish (1992). He noticed that, relative water content (RWC) was decreased in leaves by decreasing irrigation levels. Also, stated that transpiration rate of snap bean plants was decreased at the lowest irrigation regime compared to the highest regime. Under sandy soil conditions, Abou El-Khair (2004), on garlic plants, mentioned that the total and free water (%) in leaves increased where the applied irrigation water quantity increasing up to 2100 m^3 fed^{-1}, while, in deficient-watered conditions up to 600 or 1100 m^3 fed^{-1}, the bound water (%) significant increased. On sweet potato, Ayoub (2005) reported that the highest water quantity level, (4000 m^3/fed.) had favorable had a significant effect on transpiration rate and total and free water in leaf tissues, while bound water decreased by increasing water quantity.

Besides being a source of organic matter and macro and micro-nutrients, compost and vermicompost are can also improve the soil features in terms of microbial activity, hydro-physical, chemical and biological properties, as well as develop healthy and vigorous plants (Manivannan *et al.,* 2009; Mavaddati *et al.,* 2010). Compost amendments also decrease the water requirements and increase the water holding capacity WHC in the soil (Gagnon *et al*., 1998). This coupled with irrigation management can potentially decrease soil nutrient leaching, and increase yield as potatoes are sensitive to moisture fluctuation. It has been illustrated that soil moisture may be the most prominent factor in potato production as temporary dryness can reduce yield (Stamatoados *et al*., 1999). Furthermore, many kinds of research have mentioned the ability of compost to improve soil fertility, the holding capacity of water WHC, hydraulic conductivity and soil pH and also, protect the plant from various soil borne diseases (Tagoe *et al*., 2008 on soybean and Hewidy *et al*., 2015 on broccoli plants). In this regard, Hassan (2015) found that manure compost maximized the plant length, leaves number and fresh and dry weights of whole plant, in addition to the positive obvious variation in chemical constituents and yield, and so recommended using a high level of manure compost.

Ezzat *et al*. (2009) reported that the maximum water use efficiency for potato production was achieved by using humic acid or kaolin with the irrigation of 1600 m^3 fed^{-1}. Abou El-Khair *et al*. (2011) found that interaction treatment between water quantity at a rate of 1250 m^3 fed^{-1} and FYM at 30 m^3 fed^{-1} was the superior treatment for enhancing shoot dry weight per plant. While, the interaction treatment between 1750 m^3 fed^{-1} of irrigation water quantity and 30 m^3 fed^{-1} FYM increased the values of phosphorus and potassium contents and uptake by shoot, tuber yield per plant and total yield per feddan. Khalel (2015) concluded that irrigated potato plants by drip irrigation method at interval every 3 days is preferable to get the best water status for plants, in addition to the highest plant yield and total tubers yield per unit area.

Superabsorbent polymers SAPs are synthetic of hydrocarbon chains. These SAPs absorb fluids or water of greater 15 several hundred or even more than a thousand times of their weight and lose it gradually in aridity conditions in soil and frequently absorbing mission (Fazeli Rostampour, 2013; Sabbagh *et al*., 2015). Furthermore, SAPs strongly effects on hydro-physical properties of soil, prohibition soil erosion, reduction of water loss and nutrients in soil by leaching and increasing of gravity water quality (Shainberg *et al*., 2003).

Modulation of soil moisture by SAPs application led to reduction of soil apparent density by 5.5 to 9.4% which posted reflects on plant-water relationships (Bai *et al*., 2010 and Zhang *et al*., 2010).

Co-application of SAPs and humic acid or compost enhanced the plant-water relationships and drought tolerance of *Jerusalem artichoke* JA plants under aridity conditions (Ezzat *et al*., 2015).

The current study investigated the impact of the interactions of irrigation water quantities, compost and polymer on vegetative growth and water relationships of potato plants under drip irrigation system in clay loam soil.

MATERIALS AND METHODS

Plant materials and growth conditions

The experiments were performed using potatoes cv. Cara in a private farm at Meet Zonkor village, Talkha, Dakahlia Governorate, Egypt during 2016 and 2017 seasons. Mechanical, chemical and hydro-physical analyses of the soil (Tables 1 a & b) were carried out according to the methods of Page, 1982; El-Hady and El-Sherif, 1988. Imported potato half seed tubers (weighing ~ 50 g), "Elite E" were planted at hills 25 cm apart on the middle ridges. Planting took place on 7 and 9 January, for both seasons, respectively. According to the Central Management of Agriculture Guideline, Bulletin of Agricultural Meteorology, Agriculture Research Center, Egypt, Table (2) shows the temperatures and relative humidity during the growing seasons of study.

Table 1. Analytical data of the experimental site soil
(a) Mechanical and chemical analysis.

Physical properties	Value 2016	Value 2017	Chemical Properties	Value 2016	Value 2017
Sand (%)	31.8	32.4	pH value	7.4	7.9
Silt (%)	30.0	31.6	EC dSm^{-1}(in soil paste)	0.61	0.63
Clay (%)	38.2	36.0	Total N (%)	0.20	0.14
Texture class	Clay-loam	Clay-loam	Available P (ppm)	35	32
$CaCO_3$	2.4	2.6	Available K (ppm)	380	372
Organic matter (%)	2.3	2.5			

(b) Hydro-physical analysis.

Constants depth (cm)	Saturation percentage (%)		Field capacity (%)		Wilting point (%)		Available water (%)	
	2016	2017	2016	2017	2016	2017	2016	2017
0-15	78.60	78.42	38.82	38.42	16.38	16.30	18.80	19.43
15-30	79.40	80.03	39.21	39.66	16.78	16.60	19.24	19.38
30-45	80.82	80.91	40.43	40.80	16.90	16.82	20.40	20.20

Experimental arrangement, Treatments and Crop management

The field experiment plots were laid out in a strip-split plots system in randomized complete blocks design with three replicates. Three water irrigation quantities (800 "water stress condition", 1200, and 1600 "common used" m^3/fed) were occupied in the main plots (108.0 m^2). The sub-plots were divided into two compost levels (0 and 7.5 ton/fed). The strip plots were distributed four levels of polymer, i.e., 0, 10, 20, 30 kg/fed. The compost and polymer are considered as soil conditioners or dynamic procedures to increase water irrigation efficiency. Each experimental strip-plot was 13.5 m^2 comprising of three rows, 6.0 m long and 0.75 m width. Irrigation levels were applied after 1st irrigation which was 20 DAP. The treatments were continuous and pulse (15 min on/15 min off) drip irrigation systems. A distance of two meter was left between each two water irrigation levels to avert the overlapping leakage of irrigation. Drip irrigation was used from the starting to the ending of the both seasons of study. The total quantity of drip irrigation at different level was counted and expressed in terms of period established on the rate of water flow through the drippers (4 l/h.) to give such amount of water for each level or treatment (ECw = 0.8 dS/m). The amounts of applied irrigation water to main plots in each irrigation level and the period are shown in Table 3. All treatments received equal amounts of water during emergence period (100 m^3/fed.). The irrigation treatments started after 20 days from planting and were added by three days intervals. The water was added using water counter and pressure at 0.5 bar.

Table 2.*The monthly mean temperature and relative humidity during crop period in 2016 and 2017 seasons.

Months	Temperature °C						Relative humidity %					
	2016			2017			2016			2017		
	Max.	Min.	Average	Max.	Min.	Average	Max.	Min.	Average	Max.	Min.	Average
January	25.0	11.8	18.4	23.1	11.8	17.5	100.0	64.2	82.1	96	72.6	84.3
February	27.8	12.5	20.2	29.5	14.4	21.9	100.0	71.6	85.8	100	72.2	86.1
March	30.2	15.4	22.8	32.1	16.2	24.2	94.0	75.0	84.5	98	60.8	79.4
April	36.2	17.7	26.9	39.6	20.9	30.3	100.0	49.6	74.8	100	37.2	68.6
May	40.1	22.9	31.5	40.0	25.5	32.8	88.0	49.6	68.8	86	36.2	61.1

*Data from Ministry of Agriculture (Agriculture Extension Services).

Table 3. The period (minute) and quantity of applied irrigation water (m^3/fed as well as /plot) in every irrigation during the growth period of potato via dripper lines with discharge of 4 liter /h. for each dripper at 0.5 bar.

Water quantity (m^3/fed*)	Irrigation numbers	Irrigation time in every irrigation (min.)	Water quantity (m^3/fed*) in each irrigation	Water quantity (m^3/plot**) in each irrigation
800	35	78.0	22.86	20.57
1200	35	87.5	34.29	30.86
1600	35	97.0	45.72	41.14

*feddan=4200 m^2 **main plot area=108.0 m^2

Compost

The rice straw is an important raw material for compost preparation accorded with the methods of El-Hammady *et al.* (2003). Some chemical properties of the used compost were estimated according to the methods of AOAC (1990). Before planting, compost was applied to the experimental soil and left two weeks. The compost is a fine in texture, with 25.4% organic matter, C/N ratio 18.4, N 1.3%, and pH 6.8. Extractable P and K levels in the average two seasons were 0.20 and 0.84 %, respectively.

Polymers

The matrix polymers composite PMC used are the polymeric material consisting of a corn starch-based cationic cross-linked copolymer (resin matrix) of acrylamide and potassium acrylate and have hydrophilic structure. PMC was manufactured in the Insurance Agriculture Facilities and Equipment, Jiangsu Acad, Agriculture Science (Nanjing, China). The PMC is a fine white powder with 0.2-0.4 mm particle sized, 0.8 g m^{-3} bulk density, 9 x 104 % of WHC and 4.4 dS/m E.C. The substrate mixed with PMC was composed of rice straw compost, vermiculite, perlite and peat (3:2:3:2, volume/volume) and add to the plots area. Before planting, PMC mixed with substrate was applied next to the rows under seedbed in depth of 20-30 cm (maximum of root density) at the rate of 50 g.

Fertilizers program

Fertilizers used were applied for the cropping patterns in the same amounts. Macro-nutrient supply included N, P and K at rates of 180, 75 and 96 kg fed^{-1}, respectively, which were identified, promoted and adopted from the local practices. All NPK fertilizers were injected directly into the irrigation water using venture-tube into the main line of drip systems at 6 days intervals in water soluble form. Fertigation was started two weeks after sowing and was stopped 30 days prior to the end of the crop period. During the early vegetative growth, nitrogen was divided and delivered with the irrigation water in all treatments. After tuberization stage, 25 kg fed^{-1} of potassium nitrate was applied. Calcium (Calcium nitrate) at 140 mg L^{-1} and magnesium (magnesium sulphate) at 24 mg L^{-1}, Fe (Fe-EDTA) at 5 mg L^{-1}, Zn (Zn-EDTA) at 0.8 mg L^{-1}, Mn (Mn-EDTA) at 0.6 mg L^{-1} were done by preparing a nutrient solution contains these nutrients for potato. The nutrients were supplied with irrigation water (fertigation system).

All other agriculture practices of cultivation were performed as recommended by normal practices.

Measured parameters and sampling:

Nine plants were randomly chosen at ninety days after planting DAP to assess the vegetative growth characters (plant height, number of main stems per plant, fresh and dry weights of plant, and finally plant leaves area LA).

Total leaves area = (Area of the disks (cm^2) x Fresh weight of leaves per plant (g)) / Fresh weight of leaves (g) (1).

(Koller, 1972).

The Plant-water relationships were evaluated in terms of relative transpiration rate (RTR), leaf water deficit (LWD), leaf total water content (TWC) and water use efficiency (WUE). RTR was measured for a constant area (100 cm^2) of the leaves compared with an equal water surface in glass dishes; the samples were left at 30 °C for 6 h period and then estimate the weight loss from each, using the following equation:

RTR% = (weight of water loss from plant leaves/weight of water loss from water surface) x 100 (2).

LWD was evaluated by measuring the wet weight of a plant leaves taken randomly at the early morning was measured; subsequently, the saturated weight (wet weight) of the plant was assessed by placing on the surface of distilled water for 1 h until saturated; then dried in an oven and weighed DW (dry weight). The LWD was calculated (Schlemmer *et al.* (2005).

LWD% = (saturated weight - wet weight) / (saturated weight - dry weight) x 100 (2).

TWC was registered after two days of the seventh and eleventh irrigation of the three water levels using the following equation:

TWC% = (wet weight - dry weight)/wet weight x 100 (3).

WUE is known as crop yield of potatoes divided by irrigation water used to produce the total tuber yield (Begg and Turner, 1976). Thus, WUE as tuber weight (kg) gained per unit volume of irrigation water quantity as follows:

Water use efficiency = Yield (kg fed^{-1}) / Water quantity (m^3 fed^{-1}) = kg m^{-3} (4).

Statistical analysis

Data collected could be used to analyze using analysis of variance technique and the differences between individual pairs of treatment means were compared using least significant differences LSD Test at 5% according to Snedecor and Cochran (1982).

RESULTS AND DISCUSSION

Effect of the tested factors on vegetative growth of potato plants.

Slightly variation was noticed in the soil properties between the experimental years (Table 1a, b). In the 1^{st} season, the soil was higher in total nitrogen N, available phosphorus (P) and exchangeable potassium (K) than in the 2^{nd} one. The chemical composition of soil showed lower fertility than typical conditions for the production of potato. EC values in both years were lower than 4 dSm^{-1}, pointing out that the soil was not saline. Regarding the environmental conditions, there were differences in growth and biomass of potatoes over the both seasons, which may be related to a higher temperature (Table 2) and improved light conditions during the vegetative growth phase (Tang *et al*., 2018).

When compost and polymer were kept constant, irrigation water quantity led to a significant effect on biomass parameters (Table 4). Irrigation potato plants at 1600 or 1200 m^3/fed levels (without high significant differences) recorded the maximum significant values of growth parameters except for number of main stems and shoot dry weight in comparison with lowest values of irrigation treatment or stress condition (800 m^3/fed). This result confirmed the findings of Ezzat *et al*. (2009) and Eskandari *et al*. (2013). In drip irrigation system, nutrients are available, especially near the root zone might have increased the translocation of photosynthetic compounds to storage organ of potato resulting in increasing the final fresh weight. That is because of irrigation water is applied at a low rate for a longer period at repeated intervals near the plant rhizosphere through lower pressure delivery system, which increases the availability of nutrients near the plant root zone with a reduction in leaching losses of nutrients (Kumar *et al*., 2007).

Soil amendments of compost manure or polymer PMC rates had significant effects in all studied criteria as compared to control or other treatments (Table 4). Application of PMC at 3 kg/fed has significant increases in most growth traits in comparison with the control or other treatments in both seasons.

All the possible interaction effects between the two factors had significant influences of most studied parameters except for the number of main stem (Table 5).

In fact, the combined usage of compost improved the soil structure, developed a good rooting system, and thus, improved soil water holding capacity and this permitted appropriate plant provide with more water and nutrients, leading to accumulation of assimilates (Esawy *et al*., 2009; Ezzat *et al*., 2019). Moreover, PMC preserves a reasonable amount of water in the form of long-lasting gels. Supplying SAPs can raise water holding capacity WHC of soil and retardant draught stress in plants and acts as a buffering agent or soil conditioner against the water loss during the time frequent two irrigations, which in reflects on assimilates accumulation (Johnson and Leah, 1990). So, PMC has various applications in agriculture, landscaping, soil compacting, control of water/wind erosion and increase desert greening (Sabbagh *et al*., 2015).

The interaction effects among irrigation water quantities, compost and polymers led to significant increases in plant height, plant foliage DW and leaves area per plant, in both seasons (Table 5). Irrigation potatoes at 1600 or 1200 m^3/fed levels and application compost (7.5 t/fed) as soil conditioner plus polymer PMC (30 kg/fed) exhibited significant positive effects on all studied parameters, i.e., plant height, foliage fresh and dry weights and leaves area per plant compared with other treatments. No significant differences among all tested treatments were found in number of main stems per plant in two seasons.

Effect of tested factors on potatoes-water relationships and water use efficiency.

Regardless, relative transpiration rate (RTR) and leaf total water content (TWC) that further significantly reduced with deficient irrigation water (Table 6).

Application of compost or polymer PMC amendments at zero rates had increased values of RTR, leaf water deficit (LWD) and WUE during two seasons of study (Tables 6 and 7).

Irrigation water quantity x compost, compost x PMC and the PMC x irrigation water quantity interactions had significant effects on TC, RTR, LWD, TWC and WUE, in two seasons (Table 6).

Data presented in Tables (6 and 7) show that LWD of leaf tissues reduced, but RTR and TWC increased gradually with increase in irrigation water quantity combined with the high rates of compost and polymers in both growing seasons. Application of high rates of compost and polymers positively modified the deficient irrigation-affected WUE. There were good results for these parameters due to the application of compost (7.5 ton/fed) with high rate of PMC (30 kg/fed) and irrigation with 800 m^3/fed treatment (Table 7).

Irrigation with 800 m^3/fed exhibits increased in LWD and WUE. Under drought stress, PMC tends to increase in plants and plays a decisive role in regulation of mechanisms of photosynthesis and defense against oxidative stress (Eiasu *et al*., 2007).

Water stress reduced leaf TWC (Table 6) especially in 2^{nd} season, this reduction leads to a reduction in stomata conductance and availability of carbon dioxide and finally the efficiency of photosynthesis process. This combined action results in shortage of both leaves area (Table 4) and dry matter accumulation. Combination of these factors cause a decrease in net photosynthesis process at a crucial stage of tuber set and formation, consequently increase in amount of photosynthetic assimilates at this period (Wien, 1997). In the present study, adding organic compost and PMC improved leaf TWC and TC (Tables 6 and 7) which produced a higher photoassimilate in vegetative organs and thus minimized the quantity and portion of assimilates remobilization in tuber yield, especially under draught stress (Eiasu *et al*., 2007).

Table 4. Growth parameters of potatoes as influenced by water quantities, compost and polymer and their interactions in 2016 and 2017 seasons.

No.	Treatments	Plant height (cm)		No. main stems per plant		Plant fresh weight/ Plant (g)		Plant dry weight/ Plant (g)		Leaves area per plant (cm^2)	
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
					A: Water quantities (m^3/fed.)						
1	800	49.35	47.43	3.25	3.06	285.31	281.02	50.79	50.48	3935.4	3945.4
2	1200	51.55	49.46	54.05	3.16	287.17	284.07	51.30	50.98	4079.1	4061.3
3	1600	58.70	58.73	3.21	3.18	288.87	285.85	51.53	51.24	4144.8	4148.9
LSD 5%		2.24	1.51	Ns	ns	ns	3.11	ns	ns	3.7	1.9
					B: Application of compost (ton/fed.)						
1	0	49.41	48.80	3.12	3.03	269.14	266.63	48.03	47.76	3988.7	3994.6
2	7.5	56.98	54.94	3.39	3.24	305.08	300.78	54.38	54.05	4100.9	4109.2
F test		***	***	**	ns	***	***	***	***	***	***
					C: Polymers amendments (kg/fed.)						
1	0	48.52	47.38	3.12	2.90	272.25	269.58	48.59	48.50	3865.3	3871.8
2	10	52.92	50.84	3.21	3.14	285.67	282.37	50.95	50.62	3986.4	3996.8
3	20	54.51	53.02	3.26	3.23	292.21	289.15	52.29	51.75	4110.9	4118.2
4	30	56.84	56.25	3.44	3.27	298.32	293.71	53.01	52.99	4216.5	4220.8
LSD 5%		0.95	0.84	0.20	0.25	2.65	2.14	1.88	1.70	2.3	2.1
					A x B, A x C and B x C interactions						
A x B		**	ns	ns	ns	ns	*	ns	ns	***	***
A x C		**	**	ns	ns	ns	Ns	ns	ns	***	***
B x C		***	***	ns	ns	***	***	*	**	***	***

Table 5. Growth parameters of potatoes as influenced by water quantities, compost and polymer interactions in 2016 and 2017 seasons.

No.	Treatments			Plant height (cm)		No. main stems per plant		Plant fresh weight (g)		Plant dry weight (g)		Leaves area per plant (cm^2)	
	A Water quantity (m^3/fed.)	B Compost (ton/fed.)	C Polymers (kg/fed.)	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
1	800	0	0	43.11	41.19	3.00	3.00	260.00	259.11	46.43	46.27	3700.8	3709.7
2			10	45.12	42.21	3.01	3.03	263.11	260.07	46.99	46.55	3815.6	3830.8
3			20	46.87	45.11	3.22	3.11	266.11	263.80	47.52	47.35	3940.4	3953.3
4			30	50.14	49.35	3.33	3.22	271.15	269.17	48.42	48.13	4063.3	4077.3
5		7.5	0	45.33	44.11	3.10	2.70	275.60	271.05	49.21	48.47	3815.9	3819.2
6			10	53.49	50.12	3.14	3.11	305.40	300.00	54.65	53.60	3926.7	3945.4
7			20	54.48	52.16	3.20	3.16	314.27	311.40	56.66	55.61	4053.4	4052.1
8			30	56.22	55.22	4.00	3.13	326.80	314.90	57.16	57.90	4166.9	4175.3
9	1200	0	0	45.19	43.13	3.00	2.19	263.16	261.40	46.99	46.97	3803.6	3809.6
10			10	47.12	45.22	3.03	3.00	266.11	263.14	47.62	47.80	3932.5	3937.8
11			20	49.21	47.41	3.16	3.11	268.22	265.13	47.98	47.90	4054.3	4058.1
12			30	53.14	51.33	3.19	3.18	273.17	270.50	48.78	48.32	4165.2	4171.9
13		7.5	0	46.11	44.09	3.40	3.36	280.30	277.21	50.05	49.52	3943.1	3946.7
14			10	55.32	52.16	3.71	3.41	307.13	303.30	54.84	54.27	4055.7	4067.4
15			20	67.18	55.11	3.46	3.56	318.12	313.40	56.81	56.12	4278.9	4191.3
16			30	67.11	57.21	3.51	3.47	321.14	318.50	57.35	56.96	4399.7	4307.9
17	1600	0	0	50.22	51.22	3.00	3.00	271.15	268.12	48.24	47.88	3930.5	3938.9
18			10	53.35	54.15	3.13	3.11	273..11	276.19	48.77	48.25	4056.7	4060.7
19			20	54.12	55.12	3.19	3.14	275.19	272.11	49.14	48.27	4182.9	4187.4
20			30	55.33	60.21	3.19	3.21	279.22	276.80	49.50	49.43	4218.6	4199.3
21		7.5	0	61.17	60.55	3.20	3.15	283.31	280.60	50.59	50.40	3997.9	4006.8
22			10	63.12	61.20	3.22	3.17	299.17	297.50	53.42	53.25	4131.2	4138.5
23			20	65.15	63.21	3.30	3.25	311.33	309.06	55.69	55.28	4255.4	4266.8
24			30	67.11	64.15	3.44	3.39	318.44	312.40	56.86	57.20	4385.3	4392.9
LSD 5%				2.33	2.05	ns	ns	6.45	5.25	4.62	4.17	5.6	5.0

Similar results were found with those reported by Ghamari (2014). Due to a lack in the amount of irrigation, leaf LWD increased (Ezzat *et al*., 2015). Adding a maximum levels of PMC in soil, decreased the LWD whereas increased TWC (Mao *et al*., 2011). Furthermore, Ranney *et al*. (1991) reported that with osmotic modulation mechanism or accumulation of active compounds of solutes in the vacuoles there is lowering osmotic adjustment of the cells and hence engages in preserving of full turgor of cells or tissues under draught stress conductions.

Water-absorbing polymers are classified as hydrogels that cross-linked to absorb aqueous solutions through hydrogen bonding with water molecules (Kabiri, 2003). Osmotic adjustment is defined as accumulation of active solutes within the plant in response to shortage in soil water content, thus reduction of the hazard effects of water deficit. Under draught stress conditions, cell membranes are related to changes often associated with the excess in the cell turgor (Iqbal, 2009). Bai *et al.* (2010) reported that soil water content increased by 6.20 to 32.8% with the application of super absorbent polymers SAPs, while soil bulk density was reduced by 5.50 to 9.42%

closed to the control, especially with a moderate water shortage when the relative soil water contents were about 40-50%, which it turns, reflected on plant water relationships. Moreover, SAP have a good property for decreasing bulk density and increasing soil porosity and hydraulic conductivity (Zhang *et al.,* 2010).

The high levels of irrigation, e.g., with 1600 m^3/fed have been reported to lower the WUE due to deep percolation and leaching (Dalla Costa and Giovanardi, 2000). Soil application of compost significantly led to increase in the WUE for potato under all treatments of applying water levels (Tables 6 and 7). Soil amendments of compost has reported to reduce irrigation water required and evapotranspiration (Wang *et al*., 2001; Kumari, 2012) particularly in the periods before vegetation has covered the ground fully expended (Kumari, 2012). Compost and polymer improved the WUE by reducing the evapotranspiration as well as increasing the growth and tuber yield of potatoes (Kumari, 2012).

Under drip irrigation system, it could be concluded that, irrigated potatoes with water quantity of 1200 m^3/fed interacted with compost (7.5 ton/fed) and polymer (30 kg/fed) is recommended for potato grown under field conditions to maximize the growth and plant-water relationships. Additionally, the treatment increase water use efficiency WUE and decreased water requirements by 25% as compared to a common irrigation practice (1600 m^3/fed).

Table 6. Water relationships parameters of potato leaves and water use efficiency as influenced by water quantities, compost and polymer and their interactions in 2016 and 2017 seasons.

No.	Treatments	Relative transpiration rate (RTR) (%)		Leaf water deficient (LWD) (%)		Leaf total water content (TWC) (%)		Water use efficiency (WUE) (Kg/m^3)	
		2016	2017	2016	2017	2016	2017	2016	2017
A: Water quantities (m^3/fed.)									
1	800	0.302	0.300	15.028	13.550	81.430	81.206	14.425	14.767
2	1200	0.511	0.508	12.931	13.169	82.121	82.080	10.750	10.739
3	1600	0.599	0.608	12.358	12.400	82.780	82.947	8.423	8.421
LSD 5%		0.081	0.101	1.494	0.968	ns	0.764	0.825	1.579
B: Application of compost (ton/fed.)									
1	0	0.565	0.555	14.726	14.474	82.020	82.657	10.526	10.645
2	7.5	0.377	0.390	12.319	11.605	82.200	81.501	11.873	11.972
F test		***	***	*	***	*	**	***	***
C: Polymers amendments (kg/fed.)									
1	0	0.542	0.534	14.508	14.233	81.451	81.861	8.948	9.012
2	10	0.483	0.488	13.684	13.373	81.963	82.123	11.168	11.248
3	20	0.423	0.435	13.007	12.567	82.202	82.190	11.988	12.093
4	30	0.328	0.433	12.556	11.986	82.833	82.141	12.696	12.881
LSD 5%		0.063	0.058	0.602	0.639	0.213	0.218	0.431	0.503
A x B, A x C and B x C interactions									
A x B		ns	ns	ns	ns	ns	*	ns	*
A x C		ns	ns	ns	ns	ns	ns	ns	ns
B x C		ns	ns	ns	ns	ns	ns	ns	ns

Table 7. Water relationships parameters of potato leaves and water use efficiency as influenced by water quantities, compost and polymer interactions in 2016 and 2017 seasons.

No.	Treatments			Relative transpiration rate (RTR) (%)		Leaf water deficient (LWD) (%)		Leaf total water content (TWC) (%)		Water use efficiency (WUE) (Kg/m^3)	
	A Water quantity (m^3/fed.)	B Compost (ton/fed.)	C Polymers (kg/fed.)	2016	2017	2016	2017	2016	2017	2016	2017
1	800	0	0	0.467	0.453	17.050	16.373	81.416	82.577	11.408	11.421
2			10	0.426	0.420	16.693	15.400	81.873	82.267	13.442	13.929
3			20	0.393	0.367	16.047	14.720	82.247	82.087	13.933	14.317
4			30	0.373	0.360	15.393	14.037	82.542	82.097	14.779	15.609
5		7.5	0	0.220	0.233	14.737	13.393	80.257	80.447	12.746	13.108
6			10	0.227	0.237	13.867	12.700	80.493	80.587	15.221	15.179
7			20	0.123	0.133	13.340	11.390	80.727	80.123	16.104	16.467
8			30	0.187	0.198	13.100	10.383	81.887	79.493	17.767	18.104
9	1200	0	0	0.697	0.637	15.420	15.733	81.183	82.867	8.147	7.914
10			10	0.510	0.503	14.383	14.717	80.863	82.423	10.136	10.172
11			20	0.527	0.510	13.427	14.037	80.987	82.737	11.281	11.219
12			30	0.557	0.563	13.033	13.333	82.427	82.697	11.803	11.772
13		7.5	0	0.506	0.543	12.703	13.040	82.157	81.457	8.714	8.970
14			10	0.460	0.470	12.040	12.033	82.767	81.403	10.953	10.939
15			20	0.437	0.463	11.383	11.390	83.133	81.453	12.097	12.053
16			30	0.397	0.382	11.057	11.070	83.453	81.603	12.872	12.869
17	1600	0	0	0.793	0.780	15.067	14.787	82.187	82.193	6.121	6.121
18			10	0.744	0.753	14.060	14.060	82.887	82.853	7.796	7.823
19			20	0.623	0.673	13.420	13.437	82.843	83.613	8.621	8.621
20			30	0.670	0.637	12.720	13.057	82.790	83.467	8.842	8.827
21		7.5	0	0.567	0.553	12.073	12.070	81.503	81.623	6.552	6.540
22			10	0.533	0.543	11.063	11.330	82.863	83.207	9.458	9.446
23			20	0.427	0.467	10.427	10.427	83.273	83.127	9.889	9.886
24			30	0.437	0.460	12.033	10.033	83.897	83.493	10.104	10.102
LSD 5%				0.112	0.112	1.502	1.564	1.174	1.250	0.931	0.974

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تأثير استخدام الكمبوست والبوليمرات على نباتات البطاطس تحت ظروف الإجهاد المائى:
١ ـ النمو الخضرى والعلاقات المائية

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أجريت تجربة حقلية علي محصول البطاطس صنف كارا في مزرعة خاصة بقرية ميت زنقر، طلخا، محافظة الدقهلية في موسمى النمو الصيفي ٢٠١٦ و ٢٠١٧، لدراسة تأثير كمية مياه الري و الكمبوست والبوليمر بنظام الري بالتنقيط على النمو الخضرى لنباتات البطاطس والعلاقات المائية. تم استخدام تصميم القطاعات المنشقة مرتين، حيث تم توزيع كميات مياه الري (٨٠٠ "ظروف إجهاد الجفاف"، ١٢٠٠ و ١٦٠٠ م٣/فدان "المعاملة الأكثر شيوعا") بالاضافة الى الكمبوست بمعدل (٠، ٧.٥ طن/م٣) والبوليمر PMC بمعدل (٠، ١٠، ٢٠، و ٣٠ كجم/فدان) – كمهيئات للتربة – عشوائيا علي القطع المنشقة والشرائح تحت المنشقة علي الترتيب في ثلاث مكررات. ادى استخدام الكمبوست او البوليمرات تاثيرات معنوية على النمو الخضري والعلاقات المائية مقارنة بالكنترول كان للتفاعل المشترك للري مع معدل ١٢٠٠ أو ١٦٠٠ متر مكعب / فدان مع إضافات الكمبوست للتربة (٧.٥ طن / فدان) والبوليمرات (٣٠ كجم / فدان) تأثير معنوي كبير على معظم صفات النمو الخضري (ارتفاع النبات ، الوزن الجاف والمساحة الورقية) لنباتات البطاطس. أيضا أظهرت البيانات أن العلاقات المائية (معدل النتح النسبي، RTR ونقص ماء الورقة، LWD) تتأثر بشكل كبير بأعلى مستويات كمية مياه الري دون استخدام مهيئات التربة (الكمبوست والبوليمر) في كلا الموسمين. بالإضافة إلى ذلك ، أدى دمج البوليمرات مع الكمبوست تحت ظروف نقص مياه الري إلى تحسين كفاءة استخدام المياه WUE.