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Impact of Soil Amended Super-Absorbent Polymer on Growth; Yield and Water Use Utilization of Mango Cv. Zebda

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Abstract: This study was carried out during two successive seasons of 2018 and 2019 on Zebda mango tree grown on sandy soil to evaluate the effectiveness of different levels of super absorbent polymer (0, 500, 1000 and 1500 gm./tree/ year) under flood irrigation amount recommended for mango on sandy soil recommended amount of irrigation (6000 m^3/fed/year), 75 % of recommended amount of irrigation (4500 m^3/fed/ year) and 50 % of recommended amount of irrigation (3000 m^3 /fed/year) on growth, yield and water use utilization. Results show that, growth parameters of tree i.e. shoot length and thickness, number of shoots and leaf area were significantly increased by increasing the amount of applied polymer. The highest values of fruit parameters were obtained from Zebda mango trees applied with 1500gm polymer/tree/year under 75% of recommended amount of irrigation. Water use efficiency (W.U.E.) was affected with polymer and the amount of water. The highest value of W.U.E. (0.98 & 0.95 Kg fruit/m^3 water) was obtained from trees received 1500 gm polymer/tree/year under 75% of recommended amount of irrigation. According to the obtained results in this experiment, it can be concluded that using polymer at 1500g/tree/year lead to the reduction of 25% in the amount recommended of irrigation water additives by improving the efficiency of irrigation water and increase the effective area of the tree of Zebda mango on sandy soil.

Key words: Mango · Irrigation · Polymers · Yield · Water use efficiency

INTRODUCTION

Mango is known "king of fruits", mango tree is evergreen grown in tropical and subtropical regions and is consumed mainly as a fresh fruit or as a juice. Under condition of arid and semi-arid regions like Egypt, the limited supply of suitable water is considered a major problem and restricts agriculture development in desert area [1]. Proper irrigation scheduling especially during the period of plant growth and fruit development, plays vital role in the sustainability of orchard. Mango tree is considered drought resistant to some extent; however soil moisture influences the fruit size, quality and drop of immature fruits. Also moisture deficit in soil results in early maturity to fruits resulting in poor quality. Super absorbent polymer technique improve productivity with low quantity of water regime [2]. Use of super absorbent polymers (SAP) may increase water in arid and semiarid regions of the world. When inoculated super absorbent polymers (SAP) to soil affect of water volumetric content and increase significantly, as the soil dries, the stored water is released back slowly into soil [3]. Thus, plant growth could be improved with limited water supply [4]. Aswan lies on 109m above sea level. The climate in Aswan is called a desert climate. There is virtually no rainfall during the year.

The main objective of this study was to evaluate the effectiveness of different levels of super absorbent polymer (0, 500, 1000 and 1500 gm./tree/ year) under different irrigation levels on growth, yield and water use efficiency of mango cv. Zebda grown in sandy soil.

MATERIALS AND METHODS

The present study was conducted in a private farm at Aswan region (lat. 22 °N) during two successive seasons on 8 years old of Zebda mango cultivar. The chosen trees were grafted on mango seedling rootstocks, planted in sandy soilat 5 × 6 apart and irrigated with flood irrigation system. All trees under study were in full production

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Table 1: Physical and chemical properties of representative composite soil sample from the field experimental site

Chemical properties of the soil											
			Soluble Cations and anions (meq/L)				Soluble anions (meq/L)		Available Nutrients (mg kg^{-1})		
Soil depth (cm)	pH	EC dSm^{-1}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$HCO3^{-}$	Cl^{-}	N	P	K
0 - 30	7.78	1.52	4.52	2.50	7.65	0.51	0.60	12.08	36	7.0	165
30 - 60	7.81	1.6	4.76	2.66	8.06	0.54	0.64	12.72	40	7.2	180
60 - 90	7.94	1.76	5.23	2.92	8.85	0.60	0.70	13.99	43	7.8	191

Physical properties of the soil										
	Particle size distribution				Moisture content volumetric %					
	Sand	Silt	Clay	Texture class Sandy clay loam	F.C	W.P	AW	Bulk density	O. M	$CaCO_3$ %
0 - 30	61.0	5.2	33.8		21.70	11.00	10.7	1.55	0.24	3.55
30 - 60	62.8	5.0	32.2		21.35	10.75	10.6	1.52	0.26	3.65
60 - 90	65.1	5	29.9		21.00	10.50	10.50	1.49	0.29	3.70

stage and received the same horticultural practices. Analysis of the soil surface and subsurface was done according to Hesse [5] and the data are presented in (Table 1). The texture of the soil is sandy clay loam with a water table depth not less than 1.5 meters.

Two factors were studied in this research: first is irrigation water management and second is polymers and their combination on vegetative growth and yield of Zebda mango trees. Regarding irrigation water management, it is regular with mango trees farmers to add irrigation water at rate of 6000 m^3 of water/fed [6].

Thirty six of mango trees were chosen and arranged in randomized complete block design (RCBD) on twelve treatments with three replications in both seasons.

Main Plots: Irrigation Requirement Treatments:

- The amount of irrigation in the mango tree under Aswan region according to FAO [6[in the sandy soil (6000 m^3 /fed./year) under flood irrigation.
- Irrigation with 75 % of recommended amount of water (4500 m^3 /fed./year).
- Irrigation with 50 % of recommended amount of water (3000 m^3 /fed./year).

Estimation of Irrigation Water Requirements for mango tree Most of the effects of the various weather conditions are incorporated into the ETo multiplying the reference crop Evapotranspiration, ETo, by a crop coefficient, Kc according to FAO [6], the same methodology was adopted by many studies [7, 9].

$$IR = Kc \times ETo \times LF \times IE \times R \times Area\ (fed)/1000$$

where:

IR = Irrigation requirements (m^3/fed).

Kc = Crop coefficient [0.40-0.80] according to Allen *et al.* [7] and Gafar [8].

ETo = Reference crop Evapotranspiration (mm/day).

LF = Leaching fraction (assumed 20% of irrigation water).

IE = Irrigation efficiency of the irrigation system in the field (assumed 85% of the total applied).

R = Reduction factor (35-70% cover in this study).

Area = The irrigated area (one feddan = 4200 m^2).

1000 = To convert from liter to cubic meter.

Sub-Plots: Applied Polymer Materials: (We applied polymers at the mid of January around trees at 20 cm depth) According to Karimi *et al.* [9].

T1 = 0.0 gm. (no polymer) T2 = 500 gm. tree /year
T3 = 1000 gm. tree /year T4= 1500 gm. tree/ year

This superabsorbent is tripolymer of acrylamide, acrylic acid and acrylate potassium [10]. Hydrogel as super-absorbent polymer (SAP) are soil conditioners and new water-saving materials, have been widely adopted in agriculture in the advanced countries of the world. SAP materials can absorb and retain huge amounts of water so they are hydrophilic networks [2, 11].

Measurements:

Vegetative Growth: Four labeled branches (four shoots for each direction) were taken for vegetative growth (shoot length (cm), shoot thickness (cm), number of leaves/ shoot, number of shoot /tree, panicle length (cm)) in the last week of August . Leaf area was estimated using the equation given by Ahmed and Morsy [12] were measured and recorded as follows:

Leaf area (cm^2) = 0.70 (leaf length x leaf width) – 1.06

Table 2: Average monthly meteorological data of Aswan weather station during the two growth seasons of 2018 and 2019

Monthly	Temperature (°C) Max	Min	Relative humidity %	Wind speed km/day	Sunshine Hours	ETo mm/day
			2018			
January	22.9	7.2	41	273	10.8	4.28
February	28.6	12.2	29	237	11.4	5.57
March	34.2	16.7	18	241	12	7.52
April	35.6	18	17	273	12.7	8.85
May	40.9	24.6	17	275	13.3	10.27
June	42	26	16	340	13.6	11.89
July	41.3	26.4	19	315	13.5	11.21
August	41.8	26.8	20	316	13	11.03
September	41.3	25.7	22	368	12.3	11.17
October	36.8	21.4	25	264	11.6	7.96
November	28.9	14.9	37	235	10.6	5.33
December	22.9	8.7	45	251	10.7	4.02
			2019			
January	22.8	7.6	31	222	10.8	4.22
February	24.9	9.6	33	262	11.4	5.23
March	28.1	11.5	24	282	12	6.79
April	33.7	16.3	19	283	12.7	8.48
May	40.9	23.2	13	253	13.3	9.85
June	42.4	27	17	308	13.6	11.39
July	42	26.6	17	311	13.5	11.34
August	41.7	26.9	20	314	13	10.99
September	41.3	25.7	22	368	12.3	11.17
October	36.8	21.4	25	264	11.6	7.96
November	28.9	14.9	37	235	10.6	5.33
December	22.9	8.7	45	251	10.7	4.02

Yield: Yield as kg/tree was estimated at harvest by multiplying the number of fruits/tree × the average of fruit weight (g). Also, productivity per feden was estimated by multiplying the number of trees/fedan × tree yield (Kg).

Fruit Physical and Chemical Properties: At harvest, samples of five mature fruits were taken from each replicate to determine fruit length (cm), width (cm), fruit weight (g), total soluble solids (TSS %) by hand refractometer, fruit acidity (%) and vitamin C (mg/100 ml juice), were determined as described by A.O.A.C. [13].

Water Use Efficiency (W.U.E.): The water use efficiency (W.U.E) values were calculated as follows:

$$W.U.E = \frac{\text{Fruit yield (kg.)/fed}}{\text{Irrigation water applied } (m^3/\text{fed})}$$

Irrigation Water Applied (m^3/fed.): The water use efficiency (W.U.E.) was calculated considering the yield and gross water applied for the treatments, according to equation. The method was described by Ibrahim [14], W.U.E. was expressed as the amount of mango fruits in Kgs that could be produced from one cubic meter of water.

Statistical Analysis: A split plot design in 3 replicate was followed as experimental design where irrigation levels put in main plots and polymers in sub–main plot. The experimental data were tabulated and statistically analyzed according to Snedecor and Cochran [15] and the differences between mean various treatments were compared by using New L.S.D. at 5% level of probability [16].

RESULTS AND METHODS

Vegetative Growth: Data presented in Table (3) showed that both irrigation levels and polymers greatly affected number of shoots on Zebda mango tree, during studied seasons. The greatest number of shoots was recorded with the highest irrigation level (100 %) in both seasons. However, there are significant differences recorded between all irrigation treatments. The obtained data declare that water irrigation management plays an important role on number of shoots /tree in Zebda mango.

Table 3: Effect of polymer doses and irrigation levels on vegetative growth of Zebda mango cultivar during 2018 and 2019 seasons

	2018				2019			
	Irrigation levels (A)							
Polymer (g)/tree/ year	100%	75%	50%	Mean (B)	100%	75%	50%	Mean (B)
	Number of shoots / tree							
0	68.30	64.70	63.20	65.40	76.00	73.00	72.10	73.70
500	75.00	70.70	70.00	71.90	78.30	76.00	75.10	76.47
1000	76.00	76.70	74.30	75.67	91.70	79.30	79.00	83.33
1500	85.30	77.30	75.60	79.40	97.00	86.30	86.5	89.93
Mean (A)	76.15	72.35	70.78		85.75	78.65	78.18	
New L.S.D. at 5%	A = 1.438 B = 1.592 AxB = 2.432				A = 1.397 B = 1.492 AxB = 2.317			
	Shoot length (cm)							
0	17.0	15.00	12.00	14.67	16.27	15.5	13.2	14.99
500	22.5	21.50	19.00	21.00	21.3	19.67	18.83	19.93
1000	30.0	28.00	22.67	26.89	28.5	25.83	23.33	25.89
1500	33.1	30.17	24.33	29.20	30.2	27.90	25.27	27.79
Mean	25.65	23.67	19.50		24.07	22.23	20.16	
New L.S.D. at 5%	A=0.689 B=0.725 AxB =1.147				A=0.651 B=0.713 AxB =1.126			
	Shoot thickness (cm)							
0	0.73	0.60	0.4	0.58	0.49	0.40	0.60	0.50
500	0.60	0.67	0.5	0.59	0.59	0.45	0.40	0.48
1000	0.62	0.62	0.58	0.61	0.6	0.50	0.48	0.53
1500	0.70	0.67	0.55	0.64	0.63	0.60	0.59	0.61
Mean	0.66	0.64	0.51		0.58	0.49	0.52	
New L.S.D. at 5%	A=0.039 B=0.048 AxB =0.097				A=0.043 B=0.057 AxB =0.103			
	Leaf area (cm^2)							
0	21.8	19.1	13.2	18.3	22.1	19.9	13.8	18.6
500	22.2	21.2	19.5	20.97	22.5	21.9	20.2	21.53
1000	23.2	22.1	20.9	22.07	23.1	22.3	21.1	22.17
1500	23.8	23.2	22.1	23.03	23.9	23.5	22.5	23.30
Mean	22.75	21.4	18.93		22.9	21.9	19.4	
New L.S.D. at 5%	A=0.437 B=0.519 AxB =0.783				A=0.429 B=0.0.513 AxB =0.769			

Concerning shoot length data in Table (3) showed that irrigation with100% and 75% of recommended amount of water recorded the highest values and were about similar in their effect on shoot length. While irrigation with 50% recorded the least values of shoot length in both studied seasons. This data showed that irrigation with 100% or 75 % of recommended amount of water has favorite effect on shoot length of Zebda mango trees. Adding 1500 g of polymer was more effective than other concentrations or control. Improving shoot length considered a good vegetation growth parameter to avoid fruit sunburn in Zebda mango. However, 1000 and 500 g were about similar in their effect on shoot branch length. Meanwhile, untreated trees recorded the least values of shoot length in both studied seasons.

Interaction between the two studied factors was significant in most cases for both studied seasons. The highest values (33.1 and 30.2cm) were obtained by irrigation with 100% of recommended amount of water and treated with polymer at 1500 gm/tree/year in both seasons, respectively. On the other hand, the least values (12 and 13.2 cm) were recorded by irrigation at 50% of recommended amount of water without polymer.

Concerning shoot thickness of Zebda mango it was greatly affected with both studied factors. The highest values were recorded by irrigation with 100% followed by 75% of recommended amount of water. Trees treated with polymer recorded higher shoot thickness than untreated trees in both studied seasons. Generally, the highest values were obtained with 100% of recommended amount of water and 1500 gm polymer. Interaction between the two studied factors was significant in most cases, however in first season the highest interaction value (0.70cm) was recorded by irrigation with 100% of recommended amount of water and polymer at 1500 gm/tree/year. On the other hand, the least interaction value (0.40 cm) was obtained with 50% from recommended water requirements without polymer.

In addition leaf area it is clear from Table 3 that, high water irrigation level (100%) recorded the highest values and were significantly higher in their effect on leaf area. While low water irrigation level recorded the least values of leaf area in both studied seasons. Also, data showed that polymer at 1500 gm. /tree/year was more effective than other concentrations or control on increasing leaf area which considered a good vegetation growth parameter to avoid fruit sunburn in Zebda mango. However, 1000 and 500 ppm of polymer were about similar in their effect on leaf area while as untreated trees recorded the least values of leaf area in both studied seasons. Interaction between the two studied factors was significant in most cases for both studied seasons. The highest values (23.8 and 23.9 cm^2) were obtained by irrigation with 100% of recommended amount of water and polymer at 1500 gm. in both seasons, respectively. On the other hand, the least values (13.2 and 13.8 cm^2) were recorded by irrigation with 50% of recommended amount of water without polymer. These results were probably due to that polyacrylamide led to reduce the infiltration rate and improve the water holding capacity of the sandy soil, thus the soil can reserve an enough amount of water needed for roots and buds [17].

Many studies, in general, indicated that super absorbent polymers had caused an improvement in plant growth by increasing water holding capacity in soil refer to, use of super absorbent polymers (SAP) effectively increase water and fertilizer use efficiency in crops [2, 18]. Also, Banej [19] investigated the effect of a super absorbent polymers on increment of soil water efficiency, growth and establishment of *Panicum capillare*. The results illustrated that 0.3% application of this gel caused higher production of dry matter in three different soil textures (light, medium and heavy) and three irrigation period intervals (after 4, 8 and 12 days). Lawrence *et al.* [20] announced that adding super absorbent polymers to the soils held their moisture in field capacity range and caused an increase in water consumption efficiency, which is used in photosynthesis of recommended amount of water

Yield and its Components: Data obtained in Table (4) showed that the highest fruit yield (kg/tree) and productivity (ton/ fed.) was detected with irrigation with 100% of recommended amount of water followed by 75% of recommended amount of water whereas irrigation with 50% of recommended amount of water came later. However, all polymer treatments produced high fruit yield than untreated trees. The highest values of fruit yield/tree and productivity were obtained with 1500 gm./tree/year followed by 1000 gm./tree/ year whereas 500 gm./tree/year came later. The highest interaction value of fruit yield and productivity (36 & 35 kg/tree) and (4.78 & 4.65 ton/fed.) was obtained by irrigation with 100% of recommended amount of water and 1500 gm polymer. On the other hand, the lowest yield interaction value (13 & 14 kg./tree) and (1.20 & 1.15 ton/fed.) were recorded by irrigation with 50% of recommended amount of water without polymer, respectively. Trees treated with polymer at 1500 gm./tree/year and irrigated by 50% of the available water depletion is the promising treatment to reduce the total amount of irrigated water through the growing season of Zebda Mango trees. Besides, increased growth parameters and improved yield weight and fruit characteristics [21]. These results agree with those obtained by Ayman [22] on pomegranate. Also, Smith and Crassweller [23] found that, fruits yields of young apple trees was not affected by using polymer. On contrast, Shahrokhian *et al.* [24] reported that the application of polymer increased fruit weight of tomato.

Soil water content is essential to the early development of mango fruit. Super absorbent polymer affect water penetration rate, structure, texture, compactness, density and crust hardiness of soil, aggregate anchorage evaporation, soil aeration and infiltration, water tension, available water and cause better water management practices in soil [25]. Also help nutrients to release and soil nitrification, increase nutrient absorption osmotic moisture of soil and decrease transplanting stresses that cause an improvement in plant growth reaction (and increase yield and reduction in production costs of plant [2]. Nikoorazm *et al.* [26] evaluated the effects of applying SAP, irrigation regimes and polymer usage. style on lettuce growth. In his study, four levels of SAP (0, 20, 40 and 60 gr per plant), four irrigation regimes (5, 8, 11 and 14 days) and polymer usage style (layering and mixed whit soil) were performed on growth lettuce under greenhouse conditions. The results showed the high levels of SAP (60 gr per plant) increased fresh and dry weight compared to the control (without polymer) and the lowest level of polymer (20 per plant). These results indicated that high amounts of SAP had positive effects on growth lettuce.

Fruit Properties:

Physical Fruit Properties: Varying super absorbent polymer doses in different treatments had significant effect on fruit weight, diameter and length and showed how the beneficial effect and necessity of irrigation in mango production could be established in Table (5).

Table 4: Effect of polymer doses and irrigation levels on yield/tree (kg) and productivity/fed (ton) of Zebda mango cultivar during 2018 and 2019 seasons

	2018				2019			
	Irrigation levels (A)							
Polymer (g)/tree/ year	100%	75%	50%	Mean (B)	100%	75%	50%	Mean (B)
	Yield/ tree (Kg)							
0	25.00	17.00	13.00	18.30	24.00	18.00	14.00	18.70
500	31.00	22.00	17.00	23.30	31.00	21.00	18.00	23.30
1000	33.00	28.00	22.00	27.70	33.00	29.00	23.00	28.30
1500	36.00	33.00	27.00	32.00	35.00	32.00	28.00	31.70
Mean (A)	31.25	25.00	19.75		30.75	25.00	20.75	
New L.S.D. at 5%	A=1.985 B=2.013 A×B=2.971				A=1.993 B=2.143 A×B =3.017			
	Productivity/feden (ton)							
0	3.325	2.261	1.20	2.260	3.192	2.394	1.150	2.245
500	4.123	2.926	2.00	3.030	4.123	2.793	2.100	3.005
1000	4.389	3.724	2.20	3.440	4.389	3.857	2.300	3.515
1500	4.788	4.389	2.50	3.890	4.655	4.456	4.256	4.456
Mean (A)	4.160	3.330	1.975		4.090	3.325	2.502	
New L.S.D. at 5%	A=0.249 B=0.357 A×B.=0.583				A=0.264 B=0.379 A×B =0.607			

Table 5: Effect of polymer doses and irrigation levels on fruit weight, length and diameter of Zebda mango cultivar during 2018 and 2019 seasons

	2018				2019			
	Irrigation levels (A)							
Polymer (g)/tree/ year	100%	75%	50%	Mean (B)	100%	75%	50%	Mean (B)
	Fruit weight (g)							
0	368.30	350.00	300.00	306.1	380.0	365.0	250.0	331.67
500	461.70	420.30	400.00	427.33	473.3	446.7	410.0	443.33
1000	571.70	550.30	500.00	540.67	583.3	596.7	520.0	566.67
1500	695.00	560.00	510.00	588.33	713.3	626.7	590.0	643.33
Mean(A)	524.18	470.15	402.5		537.48	508.78	442.5	
New L.S.D. at 5%	A=5.415 B=5.691 A×B.=6.315				A=5.349 B=5.543 A×B.=6.387			
	Fruit length (cm)							
0	13.30	11.70	10.20	11.73	14.00	12.30	11.00	12.43
500	13.70	12.00	11.30	12.33	14.20	13.00	12.00	13.07
1000	15.80	14.70	13.50	14.67	16.30	15.30	13.50	15.03
1500	17.00	15.30	14.10	15.47	17.20	15.80	14.30	15.77
Mean(A)	14.95	13.43	12.28		15.43	14.10	12.70	
New L.S.D. at 5%	A=0.274 B=0.328 A×B =0.467				A=0.308 B=0.0.376 A×B.=0.495			
	Fruit diameter (cm)							
0	7.80	7.80	6.50	7.37	8.30	8.00	7.50	7.93
500	8.10	8.10	7.20	7.80	8.50	8.50	7.90	8.30
1000	8.40	8.30	7.50	8.07	8.80	8.70	8.00	8.50
1500	9.00	8.40	7.40	8.27	9.00	8.80	8.20	8.67
Mean(A)	8.33	8.15	7.15		8.65	8.50	7.90	
New L.S.D. at 5%	A=0.127B=0.154 A×B =0.363				A=0.138 B=0.161 A×B =0.386			

Average fruit weight, length and diameter of Zebda mango greatly affected with both studied factors during successively seasons. Highest fruit weight was recorded by 100% of recommended amount of water compared with other treatments. Super-absorbent polymer greatly increased fruit weight than untreated trees in both studied seasons. Interaction between the two studied factors was significant in most cases, the highest interaction value (695 & 713.3 gm.), (17.0 & 17.2 cm) and (9.0 & 9.0 cm) were recorded by irrigation with 100% of recommended amount of water and polymer at 1500g/tree/year. On the other hand, the least interaction value (200 &250 gm.), (10.2 & 11.0 cm) and (6.5 & 7.5cm.) were obtained with irrigation at the 50% from recommended amount of water without polymer treatment.

Table 6: Effect of polymer doses and irrigation levels on TSS (%), total acidity% and vitamin C of Zebda mango cultivar during 2018 and 2019 seasons

	2018				2019			
	Irrigation levels (A)							
Polymer (g)/tree/ year	100%	75%	50%	Mean (B)	100%	75%	50%	Mean (B)
				TSS %				
0	13.10	14.10	14.80	14.00	13.50	14.10	14.90	14.20
500	12.10	13.20	14.20	13.20	12.50	13.90	14.20	13.50
1000	12.40	13.30	14.10	13.30	12.40	13.80	14.10	13.40
1500	12.10	13.70	14.20	13.30	12.10	13.80	14.00	13.30
Mean(A)	12.40	13.60	14.30		12.60	13.90	14.30	
New L.S.D. at 5%	A=0.315 B=0.353 A×B.=0.511				A=0.296 B=0.322 A×B =0.464			
				Total acidity (%)				
0	0.66	0.68	0.67	0.67	0.67	0.68	0.68	0.68
500	0.67	0.68	0.67	0.67	0.67	0.67	0.67	0.67
1000	0.67	0.67	0.66	0.67	0.68	0.67	0.67	0.67
1500	0.68	0.68	0.67	0.67	0.68	0.66	0.67	0.67
Mean(A)	0.67	0.67	0.67		0.67	0.67	0.67	
New L.S.D. at 5%	A=N.S. B= N.S. A×B = N.S.				A= N.S. B= N.S. A×B = N.S.			
				Vitamin (C) (mg/100 ml juice)				
0	30.90	27.30	25.10	27.80	31.10	28.10	25.90	28.40
500	31.20	29.20	27.90	29.40	32.10	30.10	27.20	29.80
1000	32.20	31.20	29.20	30.90	33.10	32.10	30.10	31.80
1500	33.10	32.90	30.20	32.10	34.20	33.20	31.90	33.10
Mean(A)	31.85	30.15	28.10		32.63	30.88	28.78	
New L.S.D. at 5%	A=0.490 B=0.539 A×B =0.874				A=0.481 B=0.518 A×B = 0.857			

Chemical Fruit Properties: Fruit quality is a major concern for fruit production for its importance to human health. Improving mango fruit quality is beneficial to both growers and consumers. The taste and aroma of mango depends on concentration of sugar, total soluble solids, vitamins and amino acids in fruit. Total soluble solids, total acidity and vitamin C content of mango fruit in all treatments are listed in Table (6). Variation in irrigation water levels and polymer doses had a significant effect on the nutrition of fruit. Fruit water content is the maximum proportion and important quality in mango. Total soluble solids are a very important index of quality in mango, either less or excess irrigation water regime may decrease total soluble solids in the fruit. Results showed that there was inverse relationship between irrigation water and TSS %. The highest total soluble solids were obtained at 50% from recommended water amount which recorded 14.3 % more than the lowest total soluble solids (12.4 %) at recommended water amount. It is well known that TSS to total acidity has significant effects on food taste. There is no significant difference for total acidity content of all treatments. Vitamin C is one of the indispensable components of nutrition in mango fruit. Either excess or less irrigation water may reduce vitamin C in fruit.

The highest values of ascorbic acid were obtained with 100 % irrigation water amount in both seasons. All polymer treatments increased ascorbic acid contents of Zebda mongo during the two studied seasons compared with control, the highest values (33.1 and 34.2 mg/100 ml juice) were recorded with 100 % irrigation water amount and 1500 gm. polymer/tree/year.

Many studies in general mentioned that polyacrylamide caused an improvement by increasing nutrient absorption, osmotic potential and water holding capacity [2, 25].

Water Use Efficiency (Kg. Fruits / One M^3 Water): Water use efficiency or water use efficiency (WUE), is expressed as the amount of Zebda mango fruits in Kg. that could be produced from one cubic meter of water. WUE clearly affected by polymer and the amount of applied water. The results showed that the highest value of WUE (0.76 & 0.87 and 0.79 & 0.87 Kg/m^3) was obtained from trees applied with 1500 or 1000 gm polymer /tree/year followed by trees applied with 500 gm. while, the lowest value (0.4 & 0.38 Kg. fruit/m^3 water) was obtained from 50% from irrigation water amount without any polymer in both seasons, respectively. The recorded results in

Table 7: Effect of polymer doses and irrigation levels on water use efficiency of Zebda mango cultivar during 2018 and 2019 seasons

	2018				2019			
	Irrigation levels (A)							
Polymer (g)/tree/ year	100%	75%	50%	Mean (B)	100%	75%	50%	Mean (B)
0	0.55	0.50	0.40	0.48	0.53	0.53	0.38	0.48
500	0.68	0.65	0.67	0.67	0.69	0.62	0.70	0.67
1000	0.72	0.83	0.73	0.76	0.73	0.86	0.77	0.79
1500	0.80	0.98	0.83	0.87	0.78	0.95	0.87	0.87
Mean (A)	0.69	0.74	0.66		0.68	0.74	0.68	
New L.S.D. at 5%	A=0.037 B=0.049 A×B =0.081				A=0.041 B=0.053 A×B =0.093			

Table 8: Effect of polymer doses and irrigation levels on return economic of Zebda mango

Treatments (Water level +polymer)	Average yield (ton/fed.)	Cross income/treatment (EPG/Fed.)	Total cost (EGP)		Irrigation cost	Total cost (EGP)	Average net return (EGP)
			Fixed cost	Cost using polymer			
100%+ 0.00	3.325	26600	2800	0	1500	4300	22300
75% + 0.00	2.261	18088	2800	0	1000	3800	14288
50% + 0.00	1.2	9600	2800	0	750	3550	6050
100% + 500.00	4.123	32984	2800	4	1500	4304	28680
75% + 500.00	2.923	23384	2800	4	1000	3804	19580
50% + 500.00	2	16000	2800	4	750	3554	12446
100% + 1000.00	4.389	35112	2800	8	1500	4308	30804
75% + 1000.00	3.724	29792	2800	8	1000	3808	25984
50% + 1000.00	2.2	17600	2800	8	750	3558	14042
100% + 1500.00	4.788	38304	2800	12	1500	3562	34742
75% + 1500.00	4.389	35112	2800	12	1000	3812	31300
50% + 1500.00	2.5	20000	2800	12	750	4312	15688

Table (7) proved that irrigation with 75 % of recommended amount of water with 1500 g/tree/year gave the highest value of WUE (0.98 & 0.95 Kg fruit/m^3 water) compared with other treatments. In other words, improvement of WUE may be attributed to be available water formed in the root zone, but not the amount of applied water. These results agree with those reported by Ibrahim [14] and Kassim [2] on banana.

Return Economic: The results in Table (8) showed that the highest economic net profit (34742 EGP per fed.) was obtained from trees irrigated with 100 % of recommended amount of water and applied with 1500 g /tree/year compare with the other treatments.

CONCLUSION

The results for the study period showed that, application of polymer on mango trees with different irrigation levels led to produce good quality. Application of super absorbent polymer technique led to improve crop yield productivity with low quantity of water regime.

Applied polymer at the rate of 1500gm/tree/year with 100 % of irrigation recommended dose enhanced vegetative growth, yield and improved water use efficiency in both seasons. In the other world, super absorbent polymer is a new technique for water saving irrigation. So, we can recommended mango growers on sandy clay loam soil with flood irrigation system to irrigate with 6000m^3/fed./year plus 1500 gm./tree/year of super-absorbent polymer (SAP).

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