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Improving Maize Drought Tolerance Using Organic Residues: Towards Sustainable and Resource-Efficient Agriculture

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ABSTRACT

The water challenges facing the world force decision-makers to take measures that will reduce water requirements of the strategic plants without significantly affecting the yield. So, a field trail was executed during two successive seasons (2024 and 2025) to assess the influence of different irrigation treatments [I_1:100% of field capacity FC, I_2: 75% of FC and I_3: 50% of FC] as main factor, three regimes of fertilization [F_1:100% of NPK recommended dose RD as mineral fertilizers, F_2:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as banana residues compost, F_3:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as medicinal and aromatic plant compost] as sub main factor and two treatments of natural polymer [applied or not] as sub-sub plots on the maize performance. Growth criteria, chemical constitutes, oxidative activity, yield and its components were evaluated. The results indicated that the traditional irrigation water (I_1) outperformed the deficit treatments (I_2&I_3). Regarding fertilization treatments, the third regime (F_3 treatment) came in the first order followed by F_2 then F_1 treatments. On the other hand, the plant performance in presence of the polymer was better than in absence of the polymer. Additionally, there were no significant effect between the combined treatment of I_2 (water deficit stress) X F_2 or F_3 with polymer and the combined treatment of I_1 (traditional irrigation) X F_1 without polymer. Hence, it can be recommended to include polymer with organic fertilizer derived from medicinal and aromatic plant compost and banana residues in agricultural programs in areas suffering from water deficit.

Keywords: Water deficit, Organic Residues, Maize

INTRODUCTION

Limited water resources, raising population growth, climate change and the urgent need to expand agricultural soil to meet population requirements have made water scarcity one of the most prominent challenges facing the agricultural sector in Egypt (El-Rawy *et al.* 2019). Water scarcity directly and negatively affects higher plant growth and productivity, which compels all those involved in scientific research to develop effective agricultural strategies to maximize the use of available water resources (Abdelhafez *et al.* 2020). In this context, using the organic fertilizers has gained increasing importance, not only for their unique role in enhancing the soil physical and chemical properties, but also for their ability to improve the higher plant resistance to environmental stress such as drought (Adugna, 2016; Abdou *et al.* 2023). Compost derived from medicinal and aromatic plant residues have been shown to be effective in improving plant biological performance under water deficit circumstances due to their content of antioxidants and active natural compounds (Greff *et al.* 2023; Marcelino *et al.* 2023). Similarly, the compost of banana tree residues is a rich source of organic matter and beneficial nutrients such as potassium, as it can contribute to increasing water use efficiency and enhancing the higher plant growth under limited irrigation circumstances (El-Nour *et al.* 2015; Islam *et al.* 2021). On the other hand, natural polymers extracted from farm by product or agricultural natural waste such as potato peels provide an innovative way to enhance the irrigation water retention in the soil. Their ability to absorb large amounts of irrigation water and gradually release it to the higher plant leads to mitigate the impacts of drought as well as improves the physiological response of the higher plants grown under water deficit stress (Gebrechristos& Chen, 2018; Ahmed and Fahmy, 2019). Maize (*Zea mays* L.) is one of the strategic crop in Egypt, as it is considered as a food source for both humans and animal feed (Atta *et al.* 2022). Moreover, maize is a good model for investigating the impacts of water deficit stress due to its relative sensitivity to irrigation water shortage as well as its rapid response to different agricultural practices (Gomaa *et al.* 2017).

Therefore, the current study aims to evaluate the influence of organic fertilization with compost derived from medicinal and aromatic plants or banana residues, along with the use of a natural polymer extracted derived from potato starch on enhancing the maize plant performance under water deficit stress circumstances.

MATERIALS AND METHODS

A field trail was executed during two successive seasons (2024 and 2025) under experimental split-split plot design with three replicates in a private farm located at Meet-Anter Village, Talkha District, Dakahlia Governorate to assess the influence of different irrigation treatments [I_1:100% of field capacity FC, I_2: 75% of FC and I_3: 50% of FC] as main factor, three regimes of fertilization [F_1:100% of NPK recommended dose RD as mineral fertilizers, F_2:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as banana residues compost, F_3:75% of NPK-RD as mineral fertilizers+25% of NPK-

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RD as medicinal and aromatic plant compost] as sub main factor and two treatments of natural polymer [applied or not] as sub-sub plots on the maize performance. Soil sample as well as the both types of compost were analyzed according to Tandon, (2005), as their properties are displayed in Table 1. Irrigation quantities were adjusted according to the studied irrigation treatments using a water meter that was on the main line responsible for irrigating each main plot. The distance between each main plot was 2.0 meter to avoid irrigation water seepage and interference between irrigation treatments. Before implementing and calculating the quantities of irrigation water, a soil sample was taken and its field capacity was calculated, as it was 40%. Then, the quantities of irrigation water that achieve the studied parameters were calculated. Tensiometer was used to adjust the studied irrigation treatments. The sub-sub plot area was 1.5 m x 2.5 m (3.75 m^2). Seeds of variety named $Gold_{21}$ (single hybrid) were bought from Techno Seeds Company and were sown on April 20th of 2024 and 2025 seasons at rate of 12.0 kg fed^{-1}. All studied types of compost were added during soil preparation (before planting at two weeks) as described in the studied treatments. The two types of compost used in this research work were obtained from the Nile Compost Company - Egypt. The 100% of N (which taken from ammonium sulphate, 21%N or studied compost), P (which taken from calcium superphosphate, 15.5%P_2O_5 or studied compost) and K (which taken from potassium sulphate, 48% K_2O or studied compost) for maize is 120, 35 and 48 unit of N, P_2O_5 and K_2O fed^{-1} respectively according to the recommendations of MASR. The polymer used in this research was natural and sourced from potato peels collected from fast-food restaurants in Mansoura, Dakahlia Governorate. It was applied *via* two ways: the 1st way *via* mixing with the seeds before planting (30% of total quantity), while the 2nd way by placing into the planting holes (70% of total quantity). The application rate was 12.0 kg fed^{-1}. The polymer was prepared as described by Ahmed and Fahmy, (2019). The potato peels were thoroughly washed and dried at 60°C for 48 hours. They were then ground to a fine powder and mixed with water at a ratio of 1:10 (w/v). NaOH was added at low rate (0.3 g per one-liter of water). The mixture was then heated at 80°C for 1.0 hour with continuous stirring until it formed a gel. Harvest was carried out after 90 days from sowing. Plant height (cm), fresh and dry weights (g $plant^{-1}$) and leaf area (cm^2 $plant^{-1}$) were manually measured using traditional method at 60 days from planting. Additionally, photosynthetic pigments (Chlorophyll a & b and carotene pigments, mg g^{-1}) were spectrophotometrically estimated in fresh weight using acetone as reported by Picazo *et al.* (2013). Moreover, at the same time , the digestion of the maize straw was done using the mixture of $HClO_4$ + H_2SO_4 as described by Peterburgski, (1968) for determination of the straw chemical constitutes (NPK) using Kjeldahl (for N), spectrophotometr (for P) and flame photometer (for K) apparatuses as described by Walinga *et al.* (2013). Also at 60 days from planting, malondialdehyde (MDA, µmol g^{-1} F.W.) was determined according to the standard spectrophotometric method mentioned by Valenzuela, (1991). Catalase CAT and peroxidase POX (unit mg^{-1} protein) also were estimated *via* spectrophotometric method according to Elavarthi & Martin, (2010). At harvest stage (after 90 days from planting), the weight of ear (g), ear length and diameter (cm), No. seeds ear^{-1}, weight of 100 grain (g), grain and biological yield (ton $hectare^{-1}$), harvest index(%) were manually measured using traditional method. Seeds chemical constitutes (NPK) were determined as formerly mentioned in the straw. Additionally, carbohydrates, protein and oil (%) were estimated according to the standard methods as described in AOAC, (2000). On the other hand, soil available-N,(mg kg^{-1}) was determined at harvest stage *via* Kjeldahl method using K_2SO_4, (1%), H_3NSO_3, (2%) and devarda alloy, while soil available-P,(mg kg^{-1}) was determined at harvest stage *via* Olsen method by spectrophotometer using 0.5 M $NaHCO_3$ (pH=8.5). Soil available-K, (mg kg^{-1}) was determined at harvest stage *via* flame photometer method using $NH_4CH_3CO_2$. Cation exchange capacity (CEC, cmol kg^{-1}) of the soil at harvest stage was determined using $NH_4CH_3CO_2$ (pH 7.0). All soil properties at harvest were analyzed according to the methods mentioned by Dewis& Freitas, (1970). Data statistical analysis was executed as described by Gómez and Gómez, (1984). CoStat software (Version 6.303, Copyright, 1998-2004) at the 0.05 probability level was used in this statistical analysis.

Table 1. Properties of initial soil and both types of the studied compost

Initial soil (depth of 30 cm)			Banana residues compost	
			Characteristics	**Values**
The studied soil is clayey, having 50% clay, 30% silt and 20 % sand. Its chemical properties is as follows			C/N ratio	14.5
			K,%	1.85
			N,%	1.25
			Zn, mg kg^{-1}	19.0
			Fe, mg kg^{-1}	0.50
Characteristics		Values	Medicinal and aromatic plant compost	
EC, dSm^{-1}		2.17	Characteristics	Values
pH		8.01	C/N ratio	13.1
OM, %		1.25	K,%	1.21
Nitrogen		39.0	N,%	2.00
Phosphorus	mg kg^{-1}	6.50	Zn, mg kg^{-1}	29.3
Potassium		190	Fe, mg kg^{-1}	1.45

RESULTS AND DISCUSSION

Results

First Evaluation Stage of Plant Performance (60 Days from Planting)

Table 2 illustrates the effect of the different irrigation and fertilization regimes along with natural polymer on the growth parameters, including plant height (cm), fresh and dry weights (g $plant^{-1}$) and leaf area (cm^2 $plant^{-1}$) of maize plant (cv. $Gold_{21}$) at 60 days after planting during the growing seasons of 2024 and 2025. While the data in Tables 3 and 4 show the values of chemical parameters, including chlorophyll a & b, carotene pigments, mg g^{-1}) ,NPK (%), malondialdehyde (MDA, µmol g^{-1} F.W.), catalase CAT and peroxidase POX (unit mg^{-1} protein) as affected by the different irrigation and fertilization regimes along with natural polymer at 60 days after planting maize plant (cv. $Gold_{21}$) during the growing seasons of 2024 and 2025.

Regarding growth parameters, photosynthetic pigments and content of NPK, CAT and POX in leaves, the results indicated that the traditional irrigation water (I_1) outperformed the deficit treatments (I_2 and I_3), as the I_3 treatment came in the last order. On the contrary, the highest values of MDA were achieved with the irrigation treatment of I_3 (the highest water deficit treatment) followed by I_2 treatment and lately the I_1 treatment (traditional irrigation treatment), which recorded the maximum values. Concerning fertilization treatments, the third regime (F_3 treatment =75% of NPK-RD as mineral fertilizers+25% of NPK-RD as medicinal and aromatic plant compost) came in the first order in terms of achieving the highest values of growth parameters, photosynthetic pigments, content of N, P, K, CAT and POX in leaves, followed by F_2 treatment (75% of NPK-RD as mineral fertilizers+25% of NPK-RD as banana residues compost) then F_1 treatment (100% of NPK recommended dose RD as mineral fertilizers). On the contrary, the highest values of MDA were achieved with the fertilization treatment of F_1 followed by F_2 treatment and lately the F_3 treatment, which recorded the maximum values.

As for polymer treatments, the presence of the polymer led to the highest values of all aforementioned traits except MDA, which achieved the maximum values in absence of the polymer. The superior combined treatment, in terms of raising growth criteria and reducing the value of MDA, was when maize plants irrigated with traditional irrigation treatment (I_1), in conjunction with fertilization under the third regime (F_3 treatment =75% of NPK-RD as mineral fertilizers+25% of NPK-RD as medicinal and aromatic plant compost) in presence of the studied polymer. Additionally, there were no significant effect between the combined treatment of I_2 (water deficit stress) X F_2 or F_3 with polymer and the combined treatment of I_1 (traditional irrigation) X F_1 without polymer.

Table 2. Effect of the different irrigation and fertilization regimes along with natural polymer on the growth parameters of maize plant (cv. Gold$_{21}$) at 60 days after planting during the growing seasons of 2024 and 2025

Treatments			Plant height (cm)		Fresh weight (g/plant)		Dry weight (g/plant)		Leaf area (cm^2/plant)	
			1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Irrigation regimes										
I_1			281.75a	289.13a	947.48a	954.20a	166.22a	168.78a	878.43a	895.37a
I_2			272.40b	279.51b	868.37b	884.23b	152.00b	155.90b	832.59b	837.26b
I_3			246.00c	251.80c	768.07c	787.01c	134.19c	136.95c	752.17c	762.65c
F. test			**	**	**	**	**	**	**	**
LSD at 5%			2.39	3.11	6.98	3.41	0.82	2.56	10.16	11.23
Fertilization regimes										
F_1			261.81c	268.86c	827.95c	837.13c	144.88c	146.88c	801.86c	812.86c
F_2			267.11b	273.61b	867.14b	886.20b	153.06b	156.60b	825.91b	834.59b
F_3			271.23a	277.97a	888.82a	902.11a	154.46a	158.15a	835.42a	847.84a
F. test			**	**	**	**	**	**	**	**
LSD at 5%			1.26	1.55	8.91	5.29	0.92	0.71	7.37	4.32
Polymer treatments										
With polymer			265.36b	271.63b	852.74b	864.68b	149.49b	151.81b	811.54b	820.62b
Without polymer			267.80a	275.18a	874.40a	890.39a	152.74a	156.66a	832.94a	845.74a
F. test			**	**	**	**	**	**	**	**
LSD at 5%			2.05	1.11	2.67	3.49	0.96	1.32	5.67	6.45
Interaction										
I_1	F_1	With polymer	274.80	283.95	908.45	894.29	160.41	158.21	845.91	883.00
		Without polymer	274.87	284.14	908.05	911.36	159.20	163.81	859.73	883.85
	F_2	With polymer	279.53	285.98	949.72	966.77	169.08	171.69	875.91	885.10
		Without polymer	281.40	287.35	953.57	980.90	168.97	171.93	891.49	891.20
	F_3	With polymer	287.97	293.39	980.91	983.56	169.42	172.54	898.02	910.70
		Without polymer	291.96	299.99	984.15	988.35	170.21	174.51	899.52	918.39
I_2	F_1	With polymer	267.87	275.42	831.80	846.56	145.72	147.19	810.68	781.85
		Without polymer	270.29	276.57	833.57	847.42	147.13	150.20	811.69	820.17
	F_2	With polymer	273.28	277.75	852.19	861.05	149.37	153.67	813.06	823.50
		Without polymer	274.63	284.06	906.11	924.87	159.00	163.83	861.15	881.71
	F_3	With polymer	273.85	278.67	879.13	894.31	151.70	155.94	824.27	834.19
		Without polymer	274.50	284.62	907.41	931.16	159.09	164.57	874.65	882.14
I_3	F_1	With polymer	239.40	243.57	735.56	754.62	128.16	130.06	741.73	751.80
		Without polymer	243.64	249.53	750.26	768.53	128.65	131.83	741.42	756.48
	F_2	With polymer	243.60	250.92	753.45	776.29	135.16	138.38	747.26	756.26
		Without polymer	250.24	255.61	787.82	807.31	136.80	140.08	766.57	769.75
	F_3	With polymer	247.91	255.02	783.49	804.68	136.37	138.62	747.07	759.23
		Without polymer	251.18	256.14	797.81	810.63	139.99	142.71	768.98	782.40
F. test			**	**	**	**	**	**	**	*
LSD at 5%			6.15	3.33	8.01	10.48	2.89	3.96	17.02	19.34

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

I_1:100% of field capacity FC, I_2: 75% of FC, I_3: 50% of FC, F_1:100% of NPK recommended dose RD as mineral fertilizers, F_2:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as banana residues compost, F_3:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as medicinal and aromatic plant compost

Table 3. Effect of the different irrigation and fertilization regimes along with natural polymer on the chemical parameters of maize plant (cv. Gold$_{21}$) at 60 days after planting during the growing seasons of 2024 and 2025

Treatments			N (%)		P (%)		K (%)		Chlorophyll a (mg g^{-1})		Chlorophyll b (mg g^{-1})		Carotene (mg g^{-1})	
			1stseason	2ndseason	1stseason	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Irrigation regimes														
I_1			3.29a	3.36a	0.356a	0.365a	2.62a	2.68a	0.964a	0.962a	0.695a	0.710a	0.325a	0.331a
I_2			2.99b	3.06b	0.337b	0.344b	2.49b	2.54b	0.921b	0.932b	0.666b	0.677b	0.307b	0.313b
I_3			2.58c	2.63c	0.306c	0.313c	2.19c	2.25c	0.864c	0.880c	0.622c	0.635c	0.276c	0.282c
F. test			**	**	**	**	**	**	**	**	**	**	**	**
LSD at 5%			0.02	0.06	0.004	0.006	0.05	0.03	0.010	0.011	0.003	0.011	0.004	0.005
Fertilization regimes														
F_1			2.79c	2.85c	0.319c	0.326c	2.35b	2.40c	0.892c	0.906c	0.646c	0.659c	0.293c	0.298c
F_2			2.99b	3.06b	0.336b	0.343b	2.46a	2.51b	0.921b	0.926b	0.666b	0.678b	0.305b	0.310b
F_3			3.08a	3.14a	0.344a	0.353a	2.50a	2.56a	0.936a	0.943a	0.671a	0.685a	0.310a	0.317a
F. test			**	**	**	**	*	**	**	**	**	**	**	**
LSD at 5%			0.05	0.02	0.002	0.003	0.04	0.03	0.006	0.006	0.008	0.003	0.002	0.003
Polymer treatments														
With polymer			2.90b	2.96b	0.328b	0.34b	2.40b	2.45b	0.906b	0.921b	0.654b	0.667b	0.299b	0.304b
Without polymer			3.03a	3.10a	0.339a	0.347a	2.47a	2.53a	0.931a	0.931a	0.670a	0.684a	0.308a	0.313a
F. test			**	**	**	**	**	**	**	**	**	**	**	**
LSD at 5%			0.06	0.05	0.002	0.002	0.04	0.04	0.007	0.005	0.003	0.006	0.002	0.002
Interaction														
I_1	F_1	With polymer	3.08	3.17	0.337	0.346	2.50	2.54	0.918	0.940	0.668	0.686	0.309	0.313
		Without polymer	3.13	3.16	0.346	0.355	2.57	2.61	0.951	0.944	0.688	0.702	0.317	0.323
	F_2	With polymer	3.28	3.32	0.357	0.365	2.63	2.68	0.967	0.961	0.698	0.714	0.324	0.330
		Without polymer	3.34	3.44	0.361	0.372	2.65	2.71	0.969	0.965	0.700	0.713	0.329	0.336
	F_3	With polymer	3.42	3.49	0.368	0.376	2.67	2.75	0.985	0.977	0.706	0.722	0.334	0.341
		Without polymer	3.50	3.56	0.369	0.378	2.71	2.78	0.993	0.985	0.708	0.724	0.338	0.347
I_2	F_1	With polymer	2.82	2.88	0.324	0.332	2.38	2.42	0.892	0.906	0.638	0.653	0.291	0.296
		Without polymer	2.83	2.89	0.329	0.333	2.45	2.51	0.897	0.914	0.650	0.660	0.301	0.307
	F_2	With polymer	2.91	2.98	0.330	0.338	2.48	2.53	0.902	0.926	0.657	0.664	0.302	0.308
		Without polymer	3.18	3.26	0.349	0.355	2.58	2.63	0.958	0.949	0.691	0.702	0.320	0.324
	F_3	With polymer	3.02	3.06	0.335	0.345	2.48	2.54	0.915	0.942	0.662	0.677	0.305	0.313
		Without polymer	3.20	3.26	0.354	0.364	2.60	2.63	0.962	0.956	0.695	0.704	0.322	0.328
I_3	F_1	With polymer	2.43	2.46	0.286	0.293	2.05	2.10	0.841	0.862	0.611	0.622	0.268	0.276
		Without polymer	2.48	2.52	0.291	0.299	2.15	2.21	0.854	0.868	0.617	0.629	0.272	0.276
	F_2	With polymer	2.54	2.61	0.301	0.305	2.17	2.23	0.853	0.872	0.618	0.630	0.276	0.282
		Without polymer	2.67	2.73	0.319	0.326	2.25	2.29	0.877	0.885	0.632	0.644	0.278	0.282
	F_3	With polymer	2.59	2.64	0.317	0.325	2.23	2.29	0.875	0.899	0.624	0.633	0.278	0.282
		Without polymer	2.76	2.84	0.321	0.331	2.30	2.37	0.884	0.896	0.633	0.651	0.286	0.292
F. test			**	**	**	**	**	**	**	**	**	**	**	**
LSD at 5%			0.17	0.16	0.006	0.005	0.11	0.13	0.022	0.016	0.010	0.017	0.005	0.005

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

I_1:100% of field capacity FC, I_2: 75% of FC, I_3: 50% of FC, F_1:100% of NPK recommended dose RD as mineral fertilizers, F_2:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as banana residues compost, F_3:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as medicinal and aromatic plant compost

Table 4. Effect of the different irrigation and fertilization regimes along with natural polymer on the oxidation indicators in leaves of maize plant (cv. Gold$_{21}$) at 60 days after planting during the growing seasons of 2024 and 2025

Treatments			MDA (µmol.g^{-1} F.W)		CAT (unit mg^{-1} protein^{-1})		POX (unit mg^{-1} protein^{-1})	
			1st season	2ndseason	1st season	2nd season	1st season	2nd season
Irrigation regimes								
I_1			9.79c	9.50c	208.70a	213.37a	69.66a	71.21a
I_2			11.84b	12.10b	197.79b	202.38b	65.40b	66.68b
I_3			12.92a	13.20a	159.70c	162.71c	56.82c	58.18c
F. test			**	**	**	**	**	**
LSD at 5%			0.08	1.01	2.43	2.38	0.78	0.79
Fertilization regimes								
F_1			11.83a	11.61a	180.75c	185.29c	61.75c	62.81c
F_2			11.44b	11.68a	191.16b	194.94b	64.74b	66.30b
F_3			11.28c	11.51a	194.28a	198.24a	65.39a	66.97a
F. test			**	NS	**	**	**	**
LSD at 5%			0.08	NS	1.66	1.16	0.38	0.38
Polymer treatments								
With polymer			11.60a	11.52a	185.33b	189.39b	62.86b	64.15b
Without polymer			11.37b	11.61a	192.03a	195.95a	65.30a	66.88a
F. test			**	NS	**	**	**	**
LSD at 5%			0.07	NS	1.31	1.57	0.53	0.54
Interaction								
I_1	F_1	With polymer	10.18	7.43	196.52	200.37	67.28	68.38
		Without polymer	10.11	10.30	203.11	207.12	67.44	68.67
	F_2	With polymer	9.86	10.15	210.25	214.87	70.46	72.03
		Without polymer	9.71	9.84	211.42	216.21	70.56	72.10
	F_3	With polymer	9.56	9.76	212.00	216.87	70.81	72.66
		Without polymer	9.29	9.51	218.92	224.78	71.38	73.41
I_2	F_1	With polymer	12.45	12.65	190.72	196.25	62.51	63.16
		Without polymer	11.91	12.25	192.89	198.72	63.15	64.08
	F_2	With polymer	11.72	12.07	193.72	198.52	63.72	64.93
		Without polymer	11.66	11.86	205.62	208.39	69.07	71.10
	F_3	With polymer	11.71	11.88	195.48	198.84	63.75	65.31
		Without polymer	11.57	11.86	208.30	213.59	70.20	71.52
I_3	F_1	With polymer	13.21	13.58	146.87	151.08	54.67	56.08
		Without polymer	13.13	13.43	154.42	158.21	55.45	56.46
	F_2	With polymer	12.88	13.07	159.62	162.97	56.03	57.36
		Without polymer	12.77	13.07	166.32	168.66	58.60	60.28
	F_3	With polymer	12.85	13.06	162.83	164.73	56.47	57.46
		Without polymer	12.69	12.98	168.16	170.63	59.71	61.46
F. test			**	*	**	**	**	**
LSD at 5%			0.22	1.94	3.93	4.70	1.58	1.62

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

I_1:100% of field capacity FC, I_2: 75% of FC, I_3: 50% of FC, F_1:100% of NPK recommended dose RD as mineral fertilizers, F_2:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as banana residues compost, F_3:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as medicinal and aromatic plant compost

Second Evaluation Stage of Plant Performance (90 Days from Planting)

Table 5,6 and 7 display the influence of the studied treatments on the growth parameters, including the weight of ear (g), ear length and diameter (cm), No. seeds ear^{-1}, weight of 100 grain (g), grain and biological yield (ton $hectare^{-1}$) and harvest index (%) as well as seeds content of N, P, K, carbohydrates, protein and oil (%) of maize plant (cv. $Gold_{21}$) at 90 days after planting during the growing seasons of 2024 and 2025.

The results indicated that the traditional irrigation water (I_1) outperformed the deficit treatments (I_2&I_3). Regarding fertilization treatments, the third regime (F_3 treatment) came in the first order followed by F_2 then F_1 treatments.

On the other hand, the plant performance in presence of the polymer was better than in absence of the polymer. The superior combined treatment was when maize plants irrigated with traditional irrigation treatment (I_1), in conjunction with fertilization under the third regime (F_3 treatment =75% of NPK-RD as mineral fertilizers+25% of NPK-RD as medicinal and aromatic plant compost) in presence of the studied polymer. Additionally, there were no significant effect between the combined treatment of I_2 (water deficit stress) X F_2 or F_3 with polymer and the combined treatment of I_1 (traditional irrigation) X F_1 without polymer.

Post-harvest Soil Analyses (90 Days from Planting)

The effect of the different irrigation and natural polymer on the evaluated soil properties [available N, P, K ($mgkg^{-1}$) and CEC (cmol kg^{-1})] at 90 days after planting during the growing seasons of 2024 and 2025 was unclear, while the effect of the studied fertilization regimes on the same soil traits was crystal clear, as the F_3 treatment, which contained 25% of NPK-RD as medicinal and aromatic plant compost led to significant increase in the values of available N, P and K as well as CEC compared to F_2 treatment (which directly came after the F_1 treatment) and F_1 treatment (which came in the last order).

Table 5. Effect of the different irrigation and fertilization regimes along with natural polymer on the yield of maize plant (cv. $Gold_{21}$) at 90 days after planting during the growing seasons of 2024 and 2025

Treatments			Grain yield (ton/hectare)		Biological yield (ton/hectare)		Harvest index (%)	
			1st season	2nd season	1st season	2nd season	1st season	2nd season
Irrigation regimes								
I_1			7.01a	7.24a	13.43a	13.77a	53.42a	52.22a
I_2			6.40b	6.55b	12.53b	12.83b	52.15b	51.04b
I_3			5.05c	5.17c	11.40c	11.68c	45.31c	44.21c
F. test			**	**	**	**	**	**
LSD at 5%			0.11	0.11	0.25	0.15	1.43	0.05
Fertilization regimes								
F_1			5.75c	5.95c	12.07c	12.38c	48.41c	47.31a
F_2			6.26b	6.40b	12.54b	12.84b	50.78b	49.61b
F_3			6.45a	6.62a	12.74a	13.05a	51.69a	50.55c
F. test			**	**	**	**	**	**
LSD at 5%			0.05	0.11	0.09	0.13	0.33	0.05
Polymer treatments								
With polymer			5.98b	6.17b	12.31b	12.60b	49.54b	48.44b
Without polymer			6.37a	6.52a	12.66a	12.99a	51.09a	49.90a
F. test			**	**	**	**	**	**
LSD at 5%			0.05	0.05	0.08	0.06	0.65	0.55
Interaction								
I_1	F_1	With polymer	6.50	7.09	13.11	13.53	51.45	49.99
		Without polymer	6.96	7.12	13.13	13.55	53.88	52.69
	F_2	With polymer	7.03	7.17	13.39	13.74	53.60	52.23
		Without polymer	7.13	7.29	13.63	13.83	53.51	52.74
	F_3	With polymer	7.16	7.36	13.65	13.94	53.91	52.79
		Without polymer	7.26	7.41	13.68	14.02	54.17	52.87
I_2	F_1	With polymer	5.84	5.92	12.05	12.29	49.13	48.17
		Without polymer	5.99	6.13	12.09	12.35	50.74	49.66
	F_2	With polymer	6.22	6.39	12.18	12.40	52.52	51.57
		Without polymer	6.96	7.12	13.10	13.47	54.41	52.89
	F_3	With polymer	6.42	6.62	12.65	12.94	52.34	51.17
		Without polymer	6.97	7.13	13.11	13.52	53.77	52.75
I_3	F_1	With polymer	4.54	4.65	10.99	11.28	42.30	41.22
		Without polymer	4.66	4.76	11.07	11.30	42.98	42.10
	F_2	With polymer	4.76	4.84	11.31	11.60	42.85	41.78
		Without polymer	5.46	5.58	11.67	12.01	47.80	46.45
	F_3	With polymer	5.32	5.48	11.46	11.65	47.78	47.01
		Without polymer	5.59	5.72	11.88	12.25	48.17	46.73
F. test			**	**	**	**	*	*
LSD at 5%			0.15	0.14	0.23	0.17	1.95	1.62

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

I_1:100% of field capacity FC, I_2: 75% of FC, I_3: 50% of FC, F_1:100% of NPK recommended dose RD as mineral fertilizers, F_2:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as banana residues compost, F_3:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as medicinal and aromatic plant compost

Table 6. Effect of the different irrigation and fertilization regimes along with natural polymer on the yield components of maize plant (cv. Gold21) at 90 days after planting during the growing seasons of 2024 and 2025

Treatments			Weight of ear(g)		Ear length(cm)		Ear diameter(cm)		No. seeds ear^{-1}		Weight of 100 grain g	
			1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Irrigation regimes												
I_1			250.97a	259.47a	20.76a	22.20a	4.89a	5.10a	302.44a	315.90a	37.16a	38.28a
I_2			245.10b	251.60b	18.42b	19.79b	4.15b	4.32b	274.22b	284.78b	35.54b	36.65b
I_3			196.82c	208.63c	13.68c	14.72c	3.03c	3.15c	243.67c	250.60c	31.77c	32.81c
F. test			**	**	**	**	**	**	**	**	**	**
LSD at 5%			2.73	2.69	0.28	0.22	0.13	0.04	6.22	4.62	0.12	0.60
Fertilization regimes												
F_1			227.43b	233.74c	16.43c	17.65c	3.59c	3.73c	259.78c	270.76c	33.94c	34.91c
F_2			232.82a	238.78b	17.97b	19.13b	4.15b	4.33b	277.94b	285.79b	35.07b	36.12b
F_3			232.64a	247.18a	18.46a	19.92a	4.33a	4.50a	282.61a	294.72a	35.46a	36.72a
F. test			*	**	**	**	**	**	**	**	**	**
LSD at 5%			1.38	2.56	0.16	0.12	0.07	0.08	2.15	1.39	0.12	0.17
Polymer treatments												
With polymer			230.00b	236.68b	17.27b	18.33b	3.86b	4.02b	267.26b	279.18b	34.63b	35.47b
Without polymer			230.48a	242.36a	18.05a	19.52a	4.23a	4.41a	281.50a	290.33a	35.06a	36.38a
F. test			**	**	**	**	**	**	**	**	**	**
LSD at 5%			1.35	1.13	0.16	0.15	0.07	0.09	4.85	2.42	0.07	0.30
Interaction												
I_1	F_1	With polymer	245.11	256.80	18.77	20.43	4.37	4.60	274.67	300.05	36.00	37.06
		Without polymer	246.74	256.96	19.18	20.92	4.37	4.60	292.67	300.92	36.20	37.14
	F_2	With polymer	250.35	259.38	20.66	22.80	4.90	5.10	305.00	316.20	37.20	38.44
		Without polymer	252.32	259.96	21.29	22.84	5.20	5.40	309.33	318.63	37.32	38.59
	F_3	With polymer	254.40	261.58	22.28	22.96	5.20	5.40	309.67	329.36	37.89	38.99
		Without polymer	256.88	262.12	22.39	23.22	5.30	5.50	323.33	330.24	38.34	39.46
I_2	F_1	With polymer	240.34	247.20	16.54	18.26	3.80	3.90	258.00	272.22	34.24	35.06
		Without polymer	243.55	249.16	17.35	19.11	3.80	3.90	264.67	272.40	34.58	36.21
	F_2	With polymer	244.34	251.05	17.75	19.13	3.80	4.00	264.67	272.92	35.19	36.63
		Without polymer	248.61	254.89	19.91	21.03	4.60	4.80	293.00	301.29	36.47	37.51
	F_3	With polymer	244.59	251.34	18.54	19.53	4.10	4.30	267.33	280.11	35.98	36.71
		Without polymer	249.19	255.95	20.41	21.66	4.80	5.00	297.67	309.75	36.75	37.81
I_3	F_1	With polymer	190.67	195.86	13.06	13.33	2.50	2.60	231.67	236.26	31.23	31.84
		Without polymer	198.17	196.43	13.66	13.85	2.70	2.80	237.00	242.74	31.37	32.13
	F_2	With polymer	200.07	201.64	13.72	14.12	3.00	3.10	246.67	250.70	31.40	32.16
		Without polymer	201.24	205.77	14.47	14.85	3.40	3.60	249.00	255.00	32.82	33.38
	F_3	With polymer	200.09	205.29	14.09	14.40	3.10	3.20	247.67	254.77	32.55	32.31
		Without polymer	190.67	246.79	13.05	17.76	3.50	3.60	250.00	264.09	31.21	35.04
F. test			**	**	**	**	**	**	**	**	**	**
LSD at 5%			4.05	3.40	0.48	0.46	0.21	0.28	14.55	7.27	0.22	0.91

Means within a row followed by a different letter (s) are statistically different at a 0.05 level
I_1:100% of field capacity FC, I_2: 75% of FC, I_3: 50% of FC, F_1:100% of NPK recommended dose RD as mineral fertilizers, F_2:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as banana residues compost, F_3:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as medicinal and aromatic plant compost

Table 7. Effect of the different irrigation and fertilization regimes along with natural polymer on the quality parameters of maize plant (cv. Gold21) at 90 days after planting during the growing seasons of 2024 and 2025

Treatments			N, %		P, %		K, %		Protein, %		Carbohydrates, %		Oil, %	
			1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Irrigation regimes														
I_1			2.43a	2.48a	0.298a	0.305a	1.83a	1.87a	13.96a	14.27a	64.97a	66.35a	5.43a	5.50a
I_2			2.31b	2.36b	0.278b	0.284b	1.70b	1.73b	13.27b	13.56b	62.96b	64.47b	4.65b	4.76b
I_3			1.87c	1.91c	0.251c	0.256c	1.50c	1.53c	10.76c	11.00c	59.41a	60.73c	3.59c	3.67c
F. test			**S	**	**	**	**	**	**	**	**	**	**	**
LSD at 5%			0.05	0.02	0.003	0.007	0.04	0.02	0.28	0.12	0.17	1.73	0.12	0.13
Fertilization regimes														
F_1			2.13c	2.18c	0.264c	0.270c	1.58c	1.61c	12.26c	12.54c	61.45c	62.79c	4.08c	4.17c
F_2			2.22b	2.27b	0.279b	0.286b	1.71b	1.75b	12.75b	13.05b	62.57b	64.09b	4.71b	4.81b
F_3			2.26a	2.30a	0.285a	0.290a	1.74a	1.78a	12.98a	13.24a	63.32a	64.67a	4.88a	4.95a
F. test			**	**	**	**	**	**	**	**	**	**	**	**
LSD at 5%			0.02	0.03	0.002	0.002	0.01	0.02	0.10	0.15	0.12	0.33	0.02	0.04
Polymer treatments														
With polymer			2.17b	2.22b	0.273b	0.280b	1.64b	1.68b	12.49b	12.77b	62.12b	63.49b	4.38b	4.48b
Without polymer			2.23a	2.28a	0.280a	0.285a	1.72a	1.75a	12.82a	13.11a	62.78a	64.21a	4.79a	4.87a
F. test			**	**	**	**	**	**	**	**	**	**	**	**
LSD at 5%			0.04	0.04	0.002	0.002	0.03	0.03	0.22	0.23	0.18	0.50	0.04	0.03
Interaction														
I_1	F_1	With polymer	2.36	2.40	0.279	0.287	1.69	1.74	13.55	13.82	63.30	64.51	4.76	4.91
		Without polymer	2.36	2.43	0.284	0.289	1.72	1.75	13.59	13.97	63.34	64.56	4.85	4.94
	F_2	With polymer	2.43	2.48	0.300	0.309	1.85	1.90	13.97	14.24	64.23	66.08	5.44	5.60
		Without polymer	2.44	2.50	0.303	0.309	1.89	1.92	14.01	14.38	65.96	67.14	5.81	5.79
	F_3	With polymer	2.45	2.51	0.311	0.318	1.91	1.96	14.09	14.41	66.49	67.65	5.82	5.87
		Without polymer	2.53	2.57	0.315	0.320	1.96	1.99	14.53	14.78	66.50	68.13	5.87	5.92
I_2	F_1	With polymer	2.22	2.28	0.266	0.275	1.60	1.64	12.77	13.09	62.31	63.92	4.04	4.16
		Without polymer	2.25	2.29	0.271	0.276	1.63	1.66	12.92	13.15	62.74	64.13	4.23	4.31
	F_2	With polymer	2.29	2.34	0.274	0.281	1.66	1.70	13.15	13.46	62.80	64.16	4.50	4.60
		Without polymer	2.39	2.45	0.289	0.296	1.79	1.83	13.74	14.07	63.38	64.98	5.20	5.34
	F_3	With polymer	2.30	2.35	0.278	0.283	1.68	1.71	13.21	13.49	63.13	64.47	4.52	4.63
		Without polymer	2.41	2.45	0.291	0.296	1.82	1.85	13.84	14.07	63.40	65.15	5.40	5.51
I_3	F_1	With polymer	1.77	1.80	0.239	0.245	1.38	1.42	10.16	10.35	58.52	59.66	3.27	3.34
		Without polymer	1.84	1.89	0.243	0.248	1.46	1.48	10.58	10.85	58.50	59.95	3.31	3.38
	F_2	With polymer	1.86	1.91	0.253	0.260	1.50	1.54	10.68	10.96	58.68	60.32	3.45	3.56
		Without polymer	1.90	1.95	0.256	0.263	1.56	1.60	10.91	11.19	60.39	61.83	3.87	3.96
	F_3	With polymer	1.89	1.93	0.255	0.259	1.51	1.54	10.85	11.10	59.64	60.68	3.63	3.71
		Without polymer	1.98	2.01	0.258	0.264	1.58	1.61	11.39	11.56	60.76	61.93	4.03	4.09
F. test			*	*	**	**	**	*	*	*	**	**	**	**
LSD at 5%			0.12	0.12	0.005	0.007	0.09	0.09	0.66	0.69	0.53	1.49	0.11	0.09

Means within a row followed by a different letter (s) are statistically different at a 0.05 level
I_1:100% of field capacity FC, I_2: 75% of FC, I_3: 50% of FC, F_1:100% of NPK recommended dose RD as mineral fertilizers, F_2:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as banana residues compost, F_3:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as medicinal and aromatic plant compost

Table 8. Effect of the different irrigation and fertilization regimes along with natural polymer on some soil properties at 90 days after planting during the growing seasons of 2024 and 2025

Treatments			N, mg kg^{-1}		P, mg kg^{-1}		K, mg kg^{-1}		CEC, Cmol kg^{-1}	
			1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Irrigation regimes										
I_1			39.31c	39.84b	6.45c	6.58c	188.93c	191.05b	33.32a	33.89a
I_2			39.80b	40.35b	6.79b	6.93b	190.06b	192.91ab	33.43a	34.01a
I_3			40.93a	41.55a	7.26a	7.41a	192.10a	195.01a	33.43a	34.16a
F. test			**	*	**	**	**	*	NS	NS
LSD at 5%			0.48	0.65	0.04	0.08	0.50	3.00	NS	NS
Fertilization regimes										
F_1			38.08c	38.61c	5.52c	5.64c	186.45c	189.00b	31.54b	32.01c
F_2			40.70b	41.29b	7.40b	7.55b	191.76b	194.14a	34.16a	34.82b
F_3			41.26a	41.85a	7.58a	7.73a	192.89a	195.83a	34.49a	35.21a
F. test			**	**	**	**	**	*	*	**
LSD at 5%			0.28	0.22	0.05	0.04	0.38	2.42	0.37	0.18
Polymer treatments										
With polymer			40.29a	40.87a	6.89b	7.03b	190.56a	193.02a	32.49a	33.09b
Without polymer			40.07b	40.64b	6.96a	7.10a	190.68a	193.38a	34.50a	35.15a
F. test			**	**	**	**	NS	NS	NS	**
LSD at 5%			0.31	0.34	0.05	0.06	NS	NS	NS	0.29
Interaction										
	F_1	With polymer	38.81	39.30	5.18	5.27	185.86	187.75	30.13	30.56
		Without polymer	37.05	37.53	5.01	5.12	185.10	187.64	32.68	33.18
I_1	F_2	With polymer	40.08	40.66	7.09	7.23	190.47	192.32	33.09	33.69
		Without polymer	39.33	39.94	7.10	7.24	190.24	192.16	35.09	35.66
	F_3	With polymer	40.39	40.87	7.20	7.33	191.13	193.55	33.75	34.37
		Without polymer	40.19	40.75	7.14	7.27	190.79	192.90	35.17	35.87
	F_1	With polymer	38.18	38.68	5.56	5.66	186.27	189.18	30.92	31.45
		Without polymer	37.04	37.50	5.41	5.53	186.09	189.60	32.71	33.29
I_2	F_2	With polymer	40.82	41.33	7.32	7.48	191.54	194.92	33.35	33.87
		Without polymer	40.44	41.01	7.26	7.41	190.96	193.19	34.92	35.48
	F_3	With polymer	41.32	41.99	7.68	7.83	193.02	195.43	33.41	34.05
		Without polymer	41.02	41.60	7.53	7.67	192.49	195.14	35.25	35.89
	F_1	With polymer	38.73	39.38	6.05	6.19	187.60	189.53	30.53	31.01
		Without polymer	38.71	39.24	5.91	6.04	187.79	190.30	32.23	32.59
I_3	F_2	With polymer	41.83	42.49	7.84	8.00	194.01	196.43	33.37	34.16
		Without polymer	41.66	42.31	7.80	7.95	193.31	195.84	35.13	36.09
	F_3	With polymer	42.48	43.14	8.05	8.22	195.14	198.08	33.84	34.67
		Without polymer	42.13	42.76	7.90	8.06	194.73	199.86	35.49	36.42
F. test			*	*	**	**	**	**	**	**
LSD at 5%			0.93	1.02	0.14	0.17	1.55	2.24	0.46	0.51

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

I_1:100% of field capacity FC, I_2: 75% of FC, I_3: 50% of FC, F_1:100% of NPK recommended dose RD as mineral fertilizers, F_2:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as banana residues compost, F_3:75% of NPK-RD as mineral fertilizers+25% of NPK-RD as medicinal and aromatic plant compost

Discussion

Overall, it can be observed that water deficit treatments (I_2 & I_3) negatively affected growth, productivity and ear quality parameters of maize plants, and this was due to the importance of water for the physiological processes required by the maize plant, as well as the water content of soluble nutrients. Irrigation water shortage may have led to a decrease in the supply of nutrients and physiological activity. Also, irrigation water shortage negatively impacted the efficiency of photosynthesis and stomatal closure, which affected vegetative growth and quantitative and qualitative productivity. Furthermore, water deficit treatments (I_2 & I_3) caused a significant increase in malondialdehyde (MDA) levels compared to the traditional irrigation water (I_1), indicating an increase in oxidative stress under water stress conditions, which causes damage to cell membranes as a result of lipid peroxidation. This explains why MDA is a biomarker of oxidative damage. On the other hand, treatments using 25% of the recommended dose of NPK as compost derived from medicinal and aromatic plants or banana residues outperformed the treatment with full mineral fertilizer (NPK). This is likely due to the richness of both types of the studied compost in organic acids, active organic compounds, and microelements that improve the availability of the nutrients in the soil. Both compost types also may have contained phenolic compounds as well as growth-promoting substances like natural hormones, and this may have made them more effective. In addition to their unique role in enhancing soil health and improving microbial activity, they also feature lower nutrient losses compared to the synthetic fertilizers, which are susceptible to volatilization or leaching. As for the use of a natural polymer derived from potato peels, it may have improved the soil's hydrophilic properties. It may have conserved moisture in the root zone throughout the maize's growth period by absorbing and storing water within its network structure and gradually releasing it when moisture decreases. The positive effect of treatments F_2 and F_3 may be due to their inclusion of compost, which enhanced the soil's ability to retain nutrients. Furthermore, the organic matter in both types of compost may have formed stable complexes with cations, limiting their loss and increasing their biological efficiency. Furthermore, the slow, gradual decomposition of organic matter provides a sustainable source of nutrients over a longer period compared to rapidly soluble mineral fertilizers. The obtained results are in harmony with those of El-Nour *et*

al. (2015); Adugna, (2016); Gebrechristos& Chen, (2018); Ahmed and Fahmy, (2019); Islam *et al.* (2021); Abdou *et al.* (2023); Greff *et al.* (2023); Marcelino *et al.* (2023).

CONCLUSION

According to the results obtained, there aren't significant between the combined treatment of I_2 (water deficit stress, 75% of FC) X F_2 (banana residues compost) or F_3 (medicinal and aromatic plant compost) in presence of the natural polymer derived from potato peels and the combined treatment of I_1 (traditional irrigation, 100% of FC) X F_1 (100% of NPK recommended dose as synthetic fertilizers) in absence of the natural polymer. Hence, it can be recommended to include polymer with organic fertilizer derived from medicinal and aromatic plant compost and banana residues in agricultural programs in areas suffering from water deficit.

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تحسين مقاومة الذرة للجفاف باستخدام بقايا عضوية : نحو زراعه مستدامه وفعالة في استخدام الموارد

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الملخص

تفرض التحديات المائية التي يواجهها العالم على صانعي القرار إتخاذ تدابير تهدف إلى تقليل الإحتياجات المائية للمحاصيل الإستراتيجية دون التأثير بشكل كبير على الإنتاجية. وفي هذا السياق، تم تنفيذ تجربة حقلية خلال موسمين متتاليين (٢٠٢٤ و٢٠٢٥) لتقييم تأثير معاملات ري مختلفة [I_1: 100 %من السعة الحقلية، 75% I_2من السعة الحقلية، I_3 : ٥٠٪ من السعة الحقلية] كعامل دراسة رئيسي، وثلاث نظم للتسميد [F_1: ١٠٠٪ من الجرعة الموصى بها في صورة أسمدة معدنية، F_2: ٧٥٪ من الجرعة الموصى بها في صورة أسمدة معدنية + ٢٥٪ من كمبوست بقايا الموز، F_3: ٧٥٪ من الجرعة الموصى بها في صورة اسمده معدنية + ٢٥٪ من كمبوست النباتات الطبية والعطرية] كعامل دراسه فرعي أول، بالإضافة إلى معاملتين من البوليمر الطبيعي [مضاف أو غير مضاف] كعامل دراسة فرعي ثاني. تم تقييم مؤشرات النمو، محتوى العناصر الغذائية ، النشاط التأكسدي، المحصول ومكوناته. وقد أشارت النتائج إلى تفوق المعاملة التقليدية للري (I_1) على معاملات العجز المائي (I_2 و I_3) . بالنسبة لمعاملات التسميد، فقد جائت المعاملة الثالثة (F_3) في المرتبة الأولى تلتها المعاملة F_2 ثم المعاملة F_1 . علي جانب اخر، أظهرت النباتات التي تم معاملتها بالبوليمر الطبيعي أداءً أفضل مقارنةً بتلك التي لم تُعامل به. وعلاوة على ذلك، لم تُظهر النتائج فروقًا معنوية بين المعاملة المشتركة I_2 (معاملة عجز مائي) × F_3 او F_2 مع البوليمر، والمعاملة المشتركة I_1 (معاملة ري تقليدية) × F_1 بدون البوليمر. وعليه، يُوصى بإدراج البوليمر الطبيعي مع السماد العضوي المشتق من النباتات الطبيه والعطريه او من بقايا شجر الموز ضمن برامج التسميد الزراعي، خاصة في المناطق التي تعاني من العجز المياه.