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Impact of Disposable Diapers on the Growth of Jatroph a*curcas* Seedlings

Salim, Heba Z.; Madiha H. Zekry; I.N. Nassar and A.M. Abdallah
Dept. of Natural Resources & Agr. Eng., Faculty of Agriculture, Damanhour University

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Abstract:

The water scarcity, wide spread of sandy soil; forestry growth and the great amount of wasted diapers super absorbent polymer (SAP) are debating issues worldwide. The present study to evaluate the roles of disposable diaper on the growth of *Jatropha Curcas* seedlings. Three levels of SAP (0.0, 0.67, and 1.5%) were tested in a greenhouse experiment In addition, 15% clay treatment was used for comparison. These additives substances were mixed thoroughly with 20 kg of sandy clay loam soils. The seedlings were irrigated twice a week using 3 L of tap water (0.5 dS m^{-1}) per pot, to ensure that the seedlings were successfully established for four months. The results presented great variations in the growth parameters, wilting points (soil water contents), relative water content (RWC), cumulative evapotranspiration (ETs), evapotranspiration (ET) rates, and survival times. Some parameters were used to estimate seedlings growth magnitude. The survivability was 38, 54, 72 and 64 days for 0.0, 0.67 and 1.5 %SAP, and 15% clay treatments, respectively. The relative water contents (RWC) were 81.81, 80.0, 76.47 and 90.63% for the 0.0, 0.67 and 1.5% SAP, and 15% clay treatments, respectively. The gravimetric wilting points were 1.1, 5.2, 3.3 and 4.0 % for 0.0, 0.67 and 1.5% SAP, and clay 15% treatments, respectively. The cumulative evapotranspiration per pot was 41.32, 40.43, 71.05 and 35.08 mm for 0.0, 0.67 and 1.5% SAP, and 15% clay treatments, respectively. The overall evapotranspiration rates were 1.09, 0.75, 0.98 and 0.55 mm/day for 0.0, 0.67 and 1.5 % SAP, and 15% clay treatments, respectively. The shoot heights and branch number did not differ significantly among the treatments at drought initiation. The leaf numbers differ significantly among the treatments at both drought initiation and wilting time. The leaf growth rates were 0.176, 0.129, and 0.151d^{-1} for 0.67 and 1.5% SAP and 15% clay treatments, respectively. Therefore, the Jatropha is properly is recommended a forestry tree under limited water resources in semi-arid region using the wasted SAP of diapers.

Keywords: *SAP, Jatropha, longevity, wilting point, evapotranspiration, wasted diapers.*

1. Introduction

Demand for fresh water is increasing attendant with an increase in world population as well as climate changes that affect precipitation patterns. Usually, the agriculture is the largest consumer for fresh water, requiring approximately 80–90% of global freshwater usage (Elliott *et al.*, 2014). Increasing water use efficiency through improved cultural practices and adoption of novel technologies can result in considerable water savings in the agricultural sector (Abdallah, 2019). Several means are used to avoid the drought stress on a plant development. One promising substance that highlighted recently in the agriculture sector is using hydrogels or super absorbent polymer (SAP). These hydrogels could improve water retention, storage in soils, i.e. sandy and the water supply with low rate to plants grown. Maitra and Shukla (2014) reported that hydrogels represent a class of high-water content polymers with physical or chemical crosslinks. When polymer chains are linked together by cross-links, they lose some of their ability to move in soil as individual polymer chains. Cross-linked polymers are important because they are mechanically strong and resistant to heat, wear and solvents as well as its great amount of water absorbance. Hydrogels works as an anti-drought mechanism and reduces the water requirement of such a plant. It also reduces fertilizer application as it binds the fertilizer to the root, it reduces leaching of fertilizers. This may be accomplished through using soil amendments such as incorporation of super absorbent polymers (SAPs), more commonly known as hydrogels (Narjary *et al*., 2012).

Crops are cultivated for several purposes (foods, oil, fabric and more) for the prosperity of humankind. Some immanent trees as Jatropha trees have several uses based upon its species. The stems of hat (*Jatrophacuneata*) are used for basket making by the Seri people in Sonora and Mexico. The reddish dye that is often used is made from the root of another plant species (*Krameriagrayi*). Spicy jatropha (*J. integerrima*) is cultivated as an ornamental in the tropics for its continuously blooming crimson flowers. Buddha belly plant (*J. podagrica*) was used to tan leather and produce a red dye in Mexico and the southwestern United States. The oil from *Jatroph acurcas* is mainly converted into biodiesel for use in diesel engines. The cake resulting from oil extraction, a protein-rich product, can be used for fish or animal feed (if detoxified). It is also a biomass feedstock to power electricity plants or to produce biogas, and a high-quality organic fertilizer (Heuzé *et al*., 2016). Contradictory, there are some dangerous uses for Jatropha. Much like other members of the family *Euphorbiaceae*, members of the genus Jatropha contain several toxic compounds. The *Jatrophacurcas* seeds contain the highly poisonous toxicbum in curcin and a lectin dimer. Accidental poisoning due to its fruits and seeds has been reported in remote and tribal areas, invariably among children who often fail to recognize it. Sporadic cases often remain unreported, misdiagnosed or neglected; usually it is mass calamities which came to attention (Gupta *et al*., 2016).

Santos and Silva (2016) reported that *Jatroph acurcas* L**.,** is receiving an increase interest as a biofuel feedstock. A glasshouse experiment was performed to study the influence of water levels and the use of terracotem soil conditioners on the growth and development of *J. curcas* seedlings in the nursery. Results show a positive influence of water level on most of the growth and development parameters studied. The use of soil conditioners also did contribute to a better plant growth. A combination of moderate supply of water and soil conditioners could allow water saving of about 50% in the nursery. Rong *et al.* (2014) conducted a series of pot grown experiments to investigate effects of water, fertilizer and super absorbent polymer (SAP) on saplings growth and water use efficiency of *Jatroph acurcas L.* Two watering levels, i.e. W1: 40% ET and W2: 80% ET, two fertilizer levels, N1:0.25 g/kg and N2:0.5 g/kg) as well as two SAP levels, S1:0 g/kg and S2:2 g/kg are applied in the experiments. They reported that S2W2N2 was the best condition for the saplings of *Jatroph acurcas L.* to grow. Further, SAP can significantly improve the root system, canopy and whole plant dry mass. Also, applying SAP can suppress evapotranspiration quantity and reduce the loss of water in soil. Eventually, the water use efficiency can be improved greatly.

There are several factors control the ET such as metrological, soil surface and canopy cover conditions. The amount of water available at the evaporating surface is affected by soil amendment such as super absorbent polymer (SAP). Sand mulching combined with the SAP decreased evaporation in each layer relative to the control, which retained more water and decreased the accumulation of surface salt (Yang *et al.*, 2015 and Zhao *et al.*, 2019). The transpiration rate is a function of crop canopy, soil characteristics, SAP amended soil, and cultivation practices among others. Evapotranspiration was reduced in eight of the nine tree species grown in sandy loam, loam, silt loam and clay soils amended at 0.4% hydrogel. It is probable that soil amendment with SAP decreased the hydraulic soil conductivity that might reduce plant transpiration and soil evaporation (Agaba *et al.*, 2010). Evaporation and transpiration occur simultaneously and there is no easy way of distinguishing between the two processes. When the crop is small, water is predominately lost by soil evaporation, but once the crop is well developed and completely covers the soil, transpiration becomes the main process. At sowing nearly 100% of ET comes from evaporation, while at full crop cover more than 90% of ET comes from transpiration (Allen *et al.*,1998).

The present study aimed to evaluate the effect of super absorbent polymer (SAP) wasted from disposable diapers on evapotranspiration and the growth of Jatropha grown in sandy clay loam soil.

Table 1. Physical and chemical characterization of soil

Soil property			The value
Particle size distribution			
Sand (%)	70 %	Silt (%)	5 %
Clay (%)	25 %	Texture class	Sandy clay loam
Water retention points			
Saturation (%)			24.5 %
Field capacity (%)			20 %
PWP (%)			13.33 %
Available water (mm m^{-1})			66.67 %
Total porosity (%)			35.77 %
Saturated Hydraulic Conductivity) (mm h^{-1})			186.36
Chemical characterization			
ECe (dS m^{-1})	6.26	pH	8.16
CEC (c mol kg^{-1})	12.52	OM (%)	0.42 %
Cations (ppm)		**Anions (ppm)**	
Na^+	455	$SO4^{-2}$	112
Mg^{+2}	4.8	Cl^-	71
Ca^{+2}	48	HCO_3^-	122

2:2. Sapling greenhouse experiments

Experiments were conducted using of a woody plant (*jatropha. sp*). A one-year-old Jatropha (98.6 cm-high) seedling was collected from a private nursery in Cairo. 20 kg of the dry sandy clay loam soil were amended using recovered SAP 0.67%, SAP 1.5% and clay 15% w/w. the last treatment of clay was used as a comparison with SAP treatments. Additional 20 kg of dry sandy clay loam soil as control (0.0 SAP) was used. The seedlings were potted on April, 1st2019 in 20 L (r = 15.23 cm, length = 28 cm) pots filled with the amended soil. Five replicates were used for each additive. The seedlings were placed in a completely randomized block design in the greenhouse under an ambient condition (temperature of 28.0 ± 2.0°C and a relative humidity of 70.0 ± 5.0%). During the first 4months, the seedlings were irrigated routinely twice a week using 2 L of tap water (0.5 dS m^{-1}) per pot, to ensure that the seedlings were established successfully (Hüttermann *et al*., 1999). Unfortunately, some of *Jatropha Curcas* seedlings dried because they could not tolerate a heat/water stress status for zero SAP level. Irrigation was ceased after the four months to pursuit effects of drought stress on the saplings. Initial water content was calculated by weighing the pots (the changes in plant weights were ignored) after irrigation ceasing. The pot weights were recorded daily to obtain the daily water content (Agaba *et al*., 2010). This process was continued until seedlings became wilt. The signs of wilting were the brown leaves and brittle branches (Agaba *et al.,* 2010). The total time to reach wilting stage was considered as a survival time or longevity. The gross weight for a pot was recorded periodically to follow the soil water status. Cumulative evapotranspiration was determined from the differences between the weights (Agaba *et al.,* 2010; and Hüttermann *et al.,* 1999). Shoot heights were measured twice: at initiation drought and wilting of seedling. For determining the total dry weight of a seedling, the wilted seedlings were harvested then dried at 70°C till a constant weight.

2.3: Analysis of greenhouse measurements

Data were analyzed based upon the nonlinear regression analysis. For describing water loss or decaying the whole weight of pots under the seedlings of Jatropha as a function of time, the following polynomial was used:

$$P(x) = a \exp(-bx) + c \exp(-dx) \qquad (1)$$

Where P (x) is the polynomial value at x (time of evapotranspiration or whole weight of pots) and a, b, c and d are polynomial coefficients

The relative water content (RWC) of leaves was measured after ten days of irrigation ceases (Yamasaki and Dillenburg, 1999). Fully expanded leaves were detached, and leaf fresh weight (LFW) was measured. Six leaves were examined. They were floated on distilled water at 4 °C in a dark chamber for 24 h, and leaf turgid weight (TW) was measured. Leaf dry weight (LDW) was determined after drying at 70°C till they reached a constant weight. RWC was calculated as:

$$\text{RWC}(\%) = \frac{\text{LFW} - \text{LDW}}{\text{TW} - \text{LDW}} \text{x100} \qquad (2)$$

3. Results and Discussions

3.1. Jatropha growth:

Plate (3.1) showed the Jatropha tree before ceasing irrigation (a) and wilted tree (b). It is obvious that the tree grows vigorously just before taking place the drought condition, plate (3.1. a), but it dried at witling condition, plate (3.1. b). Before ceasing irrigation, the stored water in soil is enough for covering evapotranspiration to keep the plant survival. At the wilting condition, the soil is not able to provide the trees with water for the evapotranspiration process.

a) Ceasing irrigation

b) Wilting condition

Plate 3.1: Selected pots for Jatropha ceasing irrigation (a) and wilting condition (b)

Table (2) showed the shoot height, elongation rate of shoot and longevity under drought stress for Jatropha seedlings. The data of 0.0 SAP level were NOT presented because the seedlings dried for the majority of replicates. The shoot heights were 67.5, 83.67, and 84.33 cm for.67, 1.5 % SAP and 15 % clay, respectively, at the irrigation ceases. At the wilting condition, the corresponding values were 68.5, 87.27 and 85.27 cm. It is noticeably that the shoot heights were high at wilting time in comparison at irrigation cease time. The mean stem heights differed significantly at both times. The elongation rates of stems were 0.0.019, 0.0.050, and 0.015 cm/d for.67, 1.5% SAP and 15% clay, respectively. The rates increased as the SAP level increased. Oliveira *et al.,* (2018) reported that the growth rate of Jatropha young plants is 0.0192 g/d for zero NPK level and micronutrients in a field plot at University of Florida's Tropical Research and Educational. The survivability durations were 54, 72 and 64 days for the 0.67 and 1.5% SAP levels, and 15% clay treatments, respectively, (Table 2 and Figure 1). The survivability is a function of SAP levels and clay. It is obvious that the longevity is enhanced by SAP addition or clay to the growth media of Jatropha. The improvement of longevity is due to increasing the soil water holding capacity those concomitants with the addition of SAP or clay. The SAP rate increases, the amount of absorbed water increases, soil water retention improves, and the available water for plant increases, resulting in delaying the wilting of the plant.

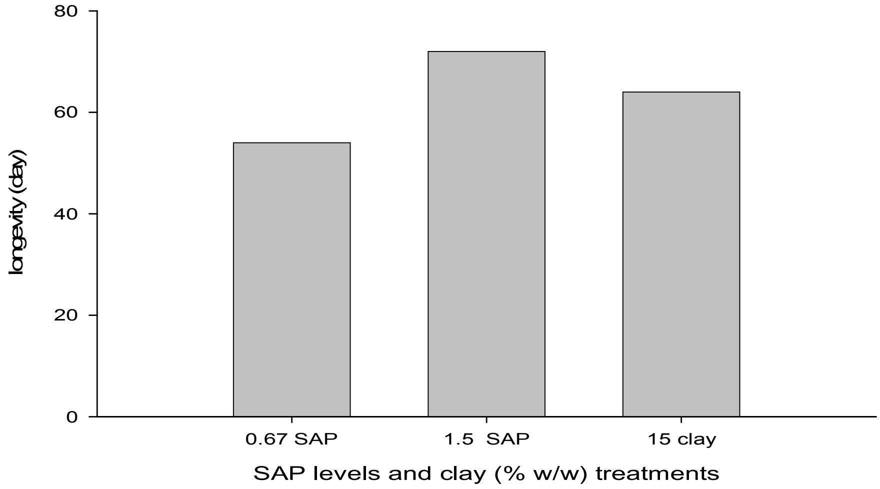

Fig. (1): Effect of SAP levels and clay on longevity of Jatropha.

Table 2. Effect of drought stress on shoot height, shoot elongation rate and longevity for Jatropha under two statuses

Treatment (%)	Shoot height (cm)		Shoot elongation rate (cm/day)	Longevity (day)
	Irrigation ceasing	Wilting time		
0.0 SAP	-----	-----	-----	---
0.67 SAP	67.50	68.50	0.019	54.0
1.5 SAP	83.67	87.27	0.050	72.0
15 clay	84.33	85.27	0.015	64.0
F (p a 0.05)	*	*		

Table (3) showed the branch number and changing rate of branches under drought stress for Jatropha seedlings. The branch numbers were 6.5, 7.33, and 7.0 for the treatments of 0.67, 1.5% SAP and 15% clay, respectively, at the initiation of drought while they were 7.0, 8.67, and 8.0 at the wilting case. There were small increases between the two events. Generally, the means of branches did not differ significantly for both times of measuring. The 1.5% SAP showed the greatest branches number for both timing. Therefore, the high soil water capacity resulted at 1.5% SAP enhanced increasing of new branches from drought initiation to wilting condition. High available water causes high nutrient availability and plant nutrients uptake too. The changing rates of branches were 0.009, 0.016, and 0.016 d^{-1} for 0 .67, and 1.5% SAP, and 15% clay, respectively. The 0.67% SAP had the lowest rate among the studied treatments.

Table 3. Effect of drought stress on branch numbers and changing rate of branches for Jatropha under two statuses of growth.

Treatment (%)	Number of branches		changing rate of branches (day^{-1})
	Irrigation ceasing	Wilting time	
0.0 SAP	--	--	--
0.67 SAP	6.5	7.0	0.009
1.5 SAP	7.33	8.67	0.016
15 clay	7	8	0.016
F (p a 0.05)	Ns	Ns	

In this section, some growth parameters will be presented for 0.67, and 1.5% SAP, and 15% clay levels at irrigation ceasing time. Because of heat/water stress, some sapling replicates of 0.0% SAP (control) were dehydrated. The 0.67, 1.5% SAP and 15% clay possessed 42, 142.33 and 146.33 leaves per pot, respectively, at the drought imitation (Table 3). The corresponding values at the wilting case were 51.5, 151.67, and 156.0. The means of leaf numbers differed significantly for both events. The 0.67% SAP presented the lowest leaf numbers as the branches number stated previously. Increasing the SAP level increased both leaf and branch numbers. The high level of SAP or clay content boosted the suitable growth factors such as available water and nutrients for a plant to grow. The leaf growth rates were presented in Table (3). These rates were 0.176, 0.129 and 0.151 day^{-1} for 0.67, 1.5% SAP and 15% clay, respectively. The leaf growth rates were not compatible with the leaf or branch numbers discussed earlier. These discrepancies in the leaf rate were due to the high longevity for 1.5 % SAP and clay treatments. For *Jatropha curcas* L. seedlings, a glasshouse experiment was performed to study the influence of water levels and the use of terracotta soil conditioners on the growth and development (Santos and Silva, 2016). Their results show a positive influence of water level on most of the growth and development parameters studied. The use of soil conditioners also did contribute to a better plant growth. SAP significantly improved the root system, canopy and whole plant dry mass of Jatropha saplings (Rong *et al.,* 2014).

Table 4. The number of leaves and leaf growth rate for Jatropha under two statuses of growth.

Treatment (%)	Number of leaves		Leaf growth rate (day^{-1})
	Irrigation ceasing	Wilting time	
0.0 SAP	-----	-----	-----
0.67 SAP	42.00	51.50	0.176
1.5 SAP	142.33	151.67	0.129
15 clay	146.33	156.00	0.151
F (p a 0.05)	*	*	

Figure (2) shows the relative water content (RWC) under the additives of SAP and clay for Jatropha. The additive clay possessed the highest RWC while the SAP of 1.5% had the lowest ones. The additive SAP suppressed the RWC in comparison to 15% clay treatment. These reductions of RWC might due to the low water supply under high SAP levels. The RWC were 80.0, 76.47, and 90.63% for the 0.67 and 1.5% SAP, and 15% clay treatments, respectively. The RWCs values of the treatments used did not differ significantly (p a 0.05). Santos *et al.,* (2018) reported similar results for the relative water contents (RWC) in *Jatropha curcas* plants under different irrigation regimes. They found the RWC of 79 and 76% for irrigated and water deficit water regimes, respectively, for non-nitrogen fertilizer pots.

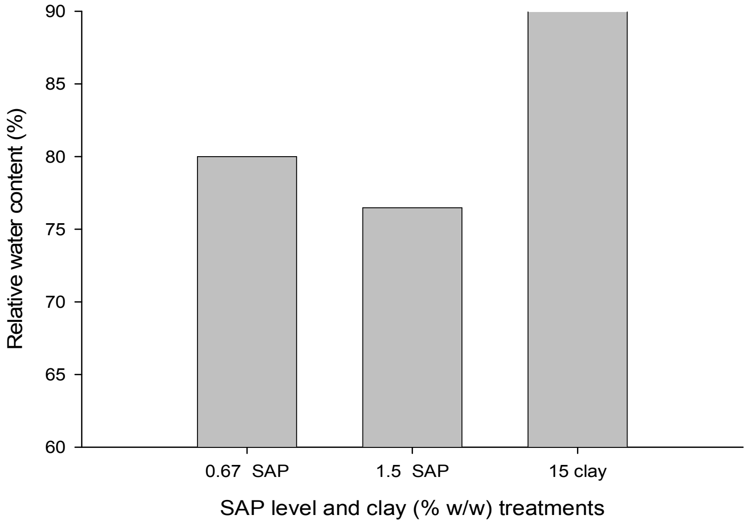

Fig. (2): Effect of SAP level and clay on the relative water content (RWC) of Jatropha.

3.2. Jatropha - SAP- water relations:

Figure (3) presents the cumulative evapotranspiration in the existence of SAP and clay amendments under Jatropha growing. The cumulative ET followed the order of 1.5%> 0.67% SAP >15% clay in the first 57 days of drought stress. The plants were removed after 57 days of drought stress because of their wilt under 0.67% SAP level. The cumulative ET increased greatly during the first five days followed by plateau stage till 40 days of drought. By further increases in time, the cumulative ET increased greatly. Evaporation from the soil surface is dominated during the first stage because there is high amount of water to supply the evaporation demand. During the plateau stage both evaporation from the soil surface and transpiration from plant control water losses. Since the soil water conductivity in a dry soil surface is a likely low for water transport, the transpiration via plant leaves controls the water losses during the late stage. The increase of transpiration is due to increase of the foliage growth. In the absence of any supply of water to the soil surface, evaporation decreases rapidly and may cease almost completely within a few days (Allen *et al.,*1998). A cubic function described the cumulative evapotranspiration under Jatropha well. The determinations coefficients for the cubic polynomial were 0.978, 0.988, and 0.989 for the 0.67 and 1.5% SAP levels, and 15% clay, respectively (Table 5). The first derivative of the polynomial represents the change rate of ET with time. The change rates at the 5th day were 0.923, 0.867 and 0.332 mm/d for 0.67 and 1.5% SAP and 15% clay, respectively. The results of change rates are concomitant with cumulative ET discussed previously. The corresponding cumulative ET rates at the 10th day were 0.630, 0.626, and 0.283 mm/day. It is obvious the rates decrease with further time in the plateau stage. It is concluded that the cumulative evapotranspiration is great in the SAP mended soil compared to the clay amended soil during the first 10 days. Similar studies, 0.4% hydrogel amendment significantly increased the plant available water by a factor of about three in sand, two in silt loam and one in sandy loam, loam and clay soils compared to the control (Agaba *et al.,* 2010). Santos and Silva (2016) studied effect of Terracotem soil conditioners *on Jatropha curcas* L., growth. They found a positive effect of the conditioner on the growth parameters. Ouattara *et al*., (2018) in Senegal, under well water supply condition, there was no significant difference between accessions of Jatropha for leave transpiration that was positively correlated to vapor pressure deficit with high values recorded between 13 h and 14 h pm.

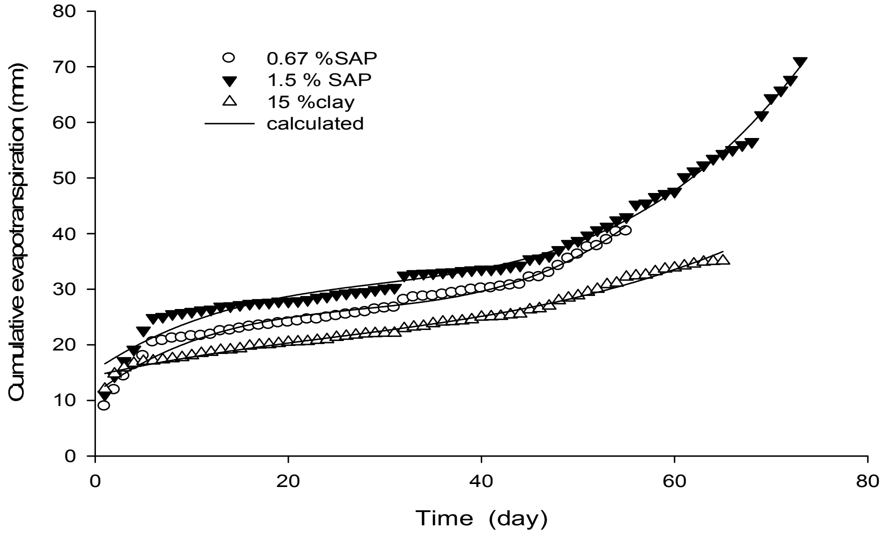

Fig. (3): Observed (symbols) and calculated (solid lines) cumalative evapotranspiration under Jatropha

Table 5. Cubic function (Eq.1) coefficients for describing the effect of time on the cumulative evapotranspration (mm), its rate (mm/day) and their R^2 under Jatropha.

Treatment (%)	Coefficients of the function				R^2	d(P)/dx (x=5)	d(P)/dx (x=10)
	a	b	c	d			
0.67 SAP	11.2909	1.2885	-0.0402	$4.8577E^{-4}$	0.978	0.9229	0.6302
1.5 SAP	15.4475	1.1595	-0.0321	$3.6210E^{-4}$	0.988	0.8656	0.6261
15 clay	14.4637	0.3959	$-7.113E^{-3}$	$9.6909E^{-5}$	0.989	0.3320	0.2827

x= time (day) and R^2 = determination coefficient.

The overall evapotranspiration under growing Jatropha for the SAP levels and clay treated soil were shown in Figure (4). The ETs were 40.43, 71.05 and 35.08 mm for 0.67 and 1.5 % SAP levels and 15 % clay treatments, respectively. These values represent water losses during the whole drought stress period. The 1.5% SAP level possessed the greatest cumulative evapotranspiration because of its high soil holding capacity and plant longevity time. The other 0.67% SAP level and 15% clay provided low value of ET compared to the 1.5% SAP level. The water availability is a vital factor controls the evapotranspiration process (Hillel, 1980). The results of Jamnická (2013) and Orikiriza *et al*., (2009) indicate that amelioration with soil conditioner significantly improved the photosynthetic performance of drought-stressed beech seedlings (*Fagussylvatica* L.) and Eucalyptus. In contrary, evapotranspiration was reduced in eight of the nine trees of Eucalyptus species grown in sandy loam, loam, silt loam and clay soils amended at 0.4% hydrogel. It is probable that soil amendment with SAP decreased the hydraulic soil conductivity that might reduce plant transpiration and soil evaporation (Agaba *et al.,* 2010). Evapotranspiration (ET) demand for Jatropha ranges between 750 and 1000 mm under optimal conditions in semi-arid tropical locations in India (Wani *et al.,* 2016). Jatropha extracted water from soil layer 150 cm below with transpiration requirements of 600–800 mm with increasing age *.Jatropha curcas*is drought tolerant, but contrary to belief, it is not a crop that requires less water: in fact, it requires 750–1000 mm water to achieve economical production.

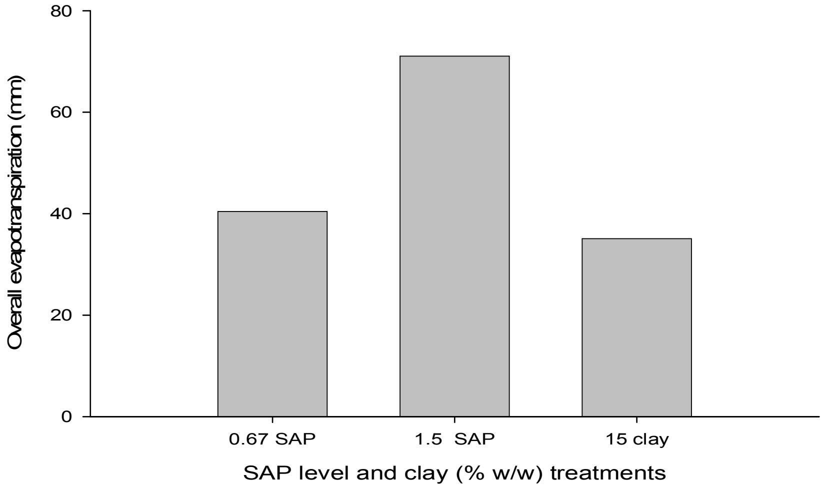

Fig. (4): Effect of SAP level and clay on overall evapotranspiration of Jatropha

The overall evapotranspiration rates are shown in Figure (5). These rates were obtained by the dividing the total cumulative evapotranspiration by the longevity of a plant. The longevity period differed among the treatments in the present study (54, 72 and 64 days for the 0.67, 1.5% SAP and 15% clay, respectively). So, the Jatrough is tolerant for drought stress. It has the ability to extract water from soil. The leaves of Jatropha might have shapes and stomata guard cells to prevent or reduce water transpiration (Allen *et al.,* 1998). The ET rates were 0.749, 0.987 and 0.548 mm/day for the 0.67, 1.5% SAP and 15% clay, respectively. Therefore, the overall evapotranspiration rates are in agreement with the comprehensive evapotranspiration and with the cumulative evapotranspiration rates presented early.

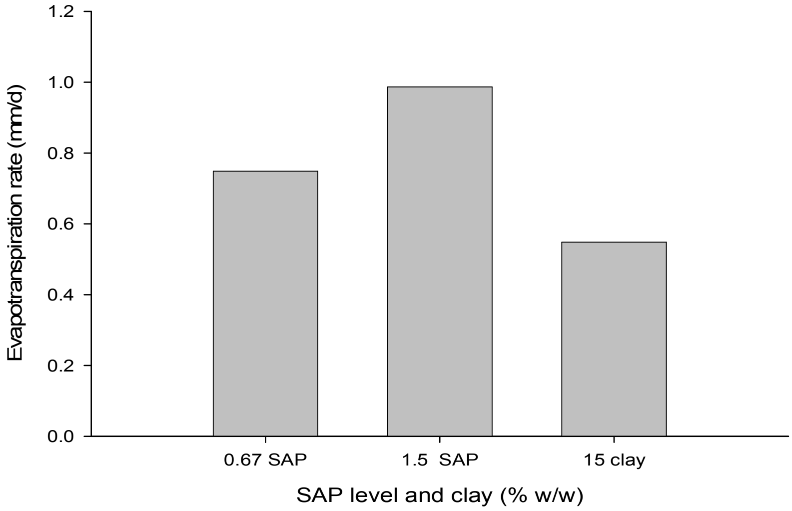

Fig. (5): Effect of SAP levels and clay on the average of evapotranspiration rate under jatropha.

Figure (5) and Table (6) present gross weights of the whole pot as a function of time. Eventually, these weights describe both changes of retained soil water and the biomass of plant as affected by drought time. The increase of a biomass can be ignored as referenced by some studies because it is not significant. Oliveira *et al.,* (2018) reported that the growth rate of Jatropha young plants is 0.0192 g/day for zero NPK level and micronutrients in a field plot at University of Florida's Tropical Research and Educational. The gross weight was described using a third polynomial (Eq. 1). The determination coefficients (R^2) of the polynomial along with its coefficients are shown in Table (6). The R^2 ranged from 0.932 for 15% clay to 0.974 for 1.5% SAP levels. These R^2 values are reliable. Therefore, the polynomial described the observed data of gross weight well. The distribution of gross weights behaved in three stages: the first stage showed a great reduction within the first 5 day of water stress, the second stage showed slight reduction similar to the plateau stage of cumulative ET declared previously and the third stage exhibited high reduction in the retained soil water with time. It is suggested that the evaporation process dominate in the first stage, both evaporation and transpiration control the second stage while the transpiration controls the third stage (Allen *et al.,* 1998). The duration of the plateau stages differed among the treatments used. The durations of these stages were approximately 30, 35, and 35 days for 0.67, and 1.5% SAP and 15 % clay, respectively. The longer the duration is the more resistance for water losses from soil. The quantity description of the retained water as a function of time can be obtained by differentiating the cubic polynomial. Table (6) shows the change rates of retained soil water after 5 and 10 days from the drought initiation. After 5 days, these absolute rates were 0.092, 0.085 and 0.045 kg/day for 0.67 and 1.5% SAP and 15% clay, respectively. The corresponding values after ten days were 0.062, 0.061, and 0.035 kg/day. These reductions of cumulative evapotranspiration or retained water rates are correlated with the hydraulic conductance of soil and plant. Root hydraulic conductance and leaf-specific hydraulic conductance decreased as water stress became more severe. Similarly by other studies, applying SAP might suppress cumulative evapotranspiration quantity and reduce the loss of soil water for saplings growth and increase water use efficiency of *Jatroph acurcas* L. (Rong *et al.,* 2014).

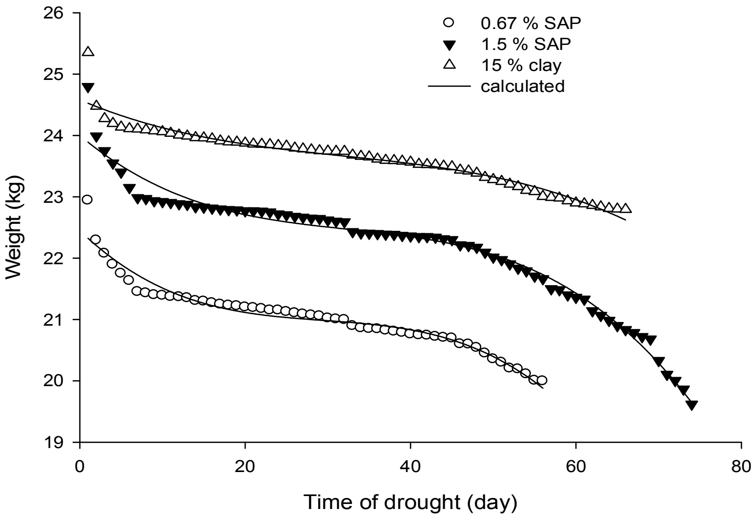

Fig. (6): Oberved (symbols) and calculated (solid line) daily weight of whole pot and plant for the SAP level and clay treatments for Jatropha

Table 6. Cubic function (Eq. 1) coefficients for the daily whole weight (kg) of pots and plant and their R^2 under Jatropha, and its rate (kg/d) and their R^2 under Jatropha.

Treatment (%)	Coefficients of the function				R^2	d(P)/dx (x=5)	d(P)/dx (x=10)
	a	b	c	d			
0.67 SAP	22.449	-0.1297	$4.0682E^{-3}$	$-4.5921E^{-5}$	0.958	-0.092	-0.06211
1.5 SAP	24.000	-0.1129	$3.0410E^{-3}$	$-3.1223E^{-5}$	0.974	-0.084	-0.06145
15 clay	24.581	-0.0577	$1.3587E^{-3}$	$-1.4166E^{-5}$	0.932	-0.045	-0.03478

x= time (day) and R^2 = determination coefficient.

Figure (7) shows the gravimetric soil water contents of wilting point for Jatropha under the SAP levels and clay treatments. The wilting points were 5.2, 3.3 and 4% for the 0.67 and 1.5% SAP levels, and 15% clay treatments, respectively. These results are in agreements with the retained soil water content stated above. The more SAP levels or clay encouraged the stored soil water. The 0.67% SAP possessed the greatest soil gravimetric in comparison to 1.5 % SAP that was lowest wilting point. Again, it is concluded that jatropha is tolerant for drought stress. Thresholds of fraction transportable soil water at transpiration declination was ranged from 0.436 to 0.302 for six Jatropha species grown in Senegal (Ouattara *et al.,* 2018). Increases of the wilting point under the additives substances are due to the retained water enhancement by these additives. The leaf shape/structure of Jatropha might reduce eventually water losses by transpiration. Under severity water deficit, *Jatropha curcas* plants presented tolerance to water deficit and used delayed dehydration as tolerance strategy (Santos *et al.,* 2018).Yin *et al.,* (2016) proved that stomata limitation to photosynthesis is dominated in *J. curcas* under low water availability. Also, under low water supply, *J. curcas* could be adapted to low water availability by adjusting its plant size, stomata closure and reduction of transpiration.

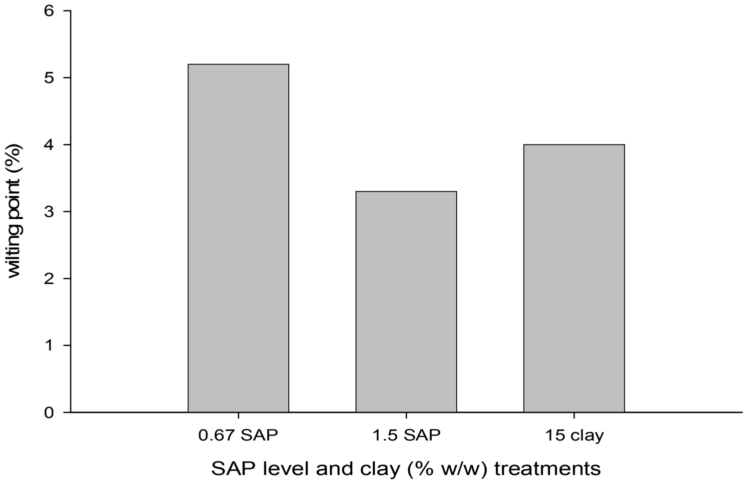

Fig. (7): Effect of SAP level and clay on the gravemetric wilting point under Jatropha.

4- Conclusion

Using 1.5% of super absorbent polymer (SAP) wasted from disposable diapers caused increasing Jatropha tree longevity and evapotranspiration rate, and caused decreasing the relative water contents (RWC) and wilting points. Therefore, the Jatropha is properly is recommended as a forestry tree under limited water resources in semi-arid region using the wasted SAP of diapers.

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اثر الحفاضات المستعملة علي نمو شتلات الجاتروفا

هبه زغلول سالم، مديحه حسن ذكري، ابراهيم نصار نصار، احمد محمد عبد الله

قسم الموارد الطبيعية والهندسة الزراعية- كلية الزراعة- جامعة دمنهور

الملخص

تعتبر حفاضات الأطفال المستخدمة مصدر قلق كبير. لذلك تم إجراء تجربة أصص في الصوبة الزراعية لتقييم إمكانية إعادة تدوير حفاضات الأطفال التي يمكن التخلص منها (البوليمرات فائقة الأمتصاصSAP) للحفاظ علي توفير الرطوبة لتربة طميية رملية على نمو شتلات الجاتروفا.

تم الحصول على شتلات الجاتروفا *Jatropha sp.* من مشتل خاص فى أبريل ٢٠١٩. وقد شملت التجربة أربعة معاملات لزراعة الشتلات هى: ٠.٠ ، ٠.٦٧ ، و ١.٥٪ من SAP و ١٥٪ من الطين للمقارنة وتم خلط هذه المواد المضافة تمامًا مع ٢٠ كجم تربة طميية رملية. تم تعبئة المخاليط في أصص بلاستيكية لزرعة الشتلات، بتصميم عشوائي كامل، خلال الأشهر الأربعة الأولى تم ري الشتلات مرتين أسبوعيًا باستخدام ٣ لتر من ماء الصنبور (٠.٥ ديسيسيمنز $^{-1}$) لكل أصيص. وقد تم تقدير فترة بقاء الجاتروفا ونسبة المحتوي المائي (RWC) و نقطة الذبول والبخر نتح و بعض قياسات النمو لنبات الجاتروفا.

وكانت بعض النتائج المتحصل عليها كالتالي:

-كانت فترة بقاء الجاتروفا ٣٨ ، ٥٤ ، ٧٢ و ٦٤ يومًا لمعاملات ٠,٠ و ٠,٦٧ و١,٥٪ SAP و ١٥٪ طين على التوالي.

-سجلت نسبة المحتوي المائي (RWC) ٨١,٨١، ٨٠,٠ ، ٧٦,٤٧ و ٩٠,٦٣٪ ، بينما نقطة الذبول سجلت ١,١، ٥,٢، ٣,٣و ٤,٠٪ لمعاملات ٠,٠ و ٠,٦٧ و ١,٥٪ SAP و ١٥٪ طين على التوالي.

- لوحظ أن قيم البخر نتح لكل أصيص ٤١,٣٢، ٤٠,٤٣، ٧١,٠٥ و٣٥,٠٨٨ مم ولكن أنخفض معدلات البخر نتح الكلية وكانت ١,٠٩، ٠,٧٥، ٠,٩٨ و ٠,٥٥ مم/يوم لمعاملات ٠,٠، ٠,٦٧ و ١,٥٪ SAP و١٥٪ طين علي التوالي.

- لوحظ عدم وجود أختلافات معنوية بين المعاملات عند بداية الجفاف لطول المجموع الخضري وعدد الافرع.

- سجلت معدلات إستطالة المجموع الخضري ٠,٠١٩، ٠,٠٥ و ٠,٠١٥سم/يوم، بينما معدلات تغير الأفرع كانت ٠,٠٠٩، ٠,٠١٦ و ٠,٠١٦لكل يوم لمعاملات ٠,٦٧ و ١,٥٪ SAP و١٥٪ طين علي التوالي.

بالملاحظ زاد طول عمر الجاتروفا مع استخدام SAP بمعدل١,٥٪ كما زاد البخر نتح التراكمي تحت جاتروفا بينما قلت نسبة المحتوي المائي ونقطة الذبول. لذلك، يوصى باستخدام البوليمر فائق الامتصاص (SAP) المهدر من الحفاضات عند زراعة الجاتروفا كشجرة غابات في ظل موارد مائية محدودة في المناطق الجافة وشبه الجافه.