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Mulching Implication on Productivity and Fruit Quality of Pomegranate Grown In A Sandy Soil

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THIS STUDY was carried out during two successive seasons (2012 and 2013) on 4 - years old pomegranate trees, (*Punica granatum* L.) wonderful cv., grown on a sandy soil under drip irrigation to assess four different mulching treatments, rice straw, palm fronds, transparent polyethylene sheets and gravel on tree growth and their productivity. The design of the experiment is randomized complete block five treatments with three replicates each.

Gravel mulch gave the highest number of leaves, shoot length, number of internodes, as well as length, diameter, volume, aril weight per fruit, fruit weight and yield. Rice straw gave the highest total soluble solids, Vitamin (C), total rind and juice anthocyanin. Gravel and rice straw mulch were more effective in reducing cracked fruits and decrease sunburn disorder. Mulching treatments reduced grass growth and increased moisture and soil temperature conservation, in particular of gravel mulch which was superior in this concern. It can be recommended that gravel mulching was the most effective treatment to improve soil moisture, growth, quality and productivity of pomegranate fruits.

Keyword: Pomegranate (Wonderful cv.), Rice straw mulch, Palm fronds mulch, Transparent polyethylene mulch, Gravel mulch. Soil temperature, Soil moisture.

Pomegranate (*Punica granatum* L.) belongs to the family *puniceae*, and is a favorite table fruit of tropical and subtropical regions of the world (Abubakr *et al*., 2013). Also, it has been grown in the moderate climate of the Mediterranean region. This tree species is well adapted to marginal lands and arid soils (Ozguuven *et al*., 2009 and Sawarsan *et al*., 2011). It has been cultivated from ancient times for its economic, ornamental, and medicinal properties. Globally pomegranate fruits are rather eaten fresh or used as syrup. (Abubakar *et al*., 2013) .The wonderful pomegranate cultivar is one of the most widely grown in the world (Melgaejo *et al*., 2012), which fits market requirements, namely: deep red color of skin and arils and large size (Frank, 2012). In recent years, the demand has increased for increasing areas of pomegranate to face the needs of both local and foreign markets (Saeed, 2004). The total cultivated area of pomegranate in Egypt reached 26351feddans, with total fruit production of 89035 metric tons (according to the latest statistics of the Ministry of Agriculture (2012).

Pomegranate growing is still facing many problems and procedures must be developed for better crop management (Rao and Subramanyam, 2010). Hence, improve crop management through development of appropriate research is the only alternative for better crop yield and quality (Chin *et al*., 2001). Agricultural management practices can change the soil surface and influence the hydrothermal properties of the soil. For example, mulching can affect the temperature and moisture content of the soil (Acharya *et al*., 2005), and directly influence crop yield (Liu, *et al*., 2014). The benefits of using mulch in orchards have been reported in many parts of the world to protect plants from extreme transpiration fluctuation (Liu *et al*., 2014), and regulation of soil temperature (Liang *et al*., 2002). In addition, soil temperature is very critical for biological and chemical process that control nutrient cycling (Donk Van *et al*., 2004). Moreover, using mulches help in moisture conservation and reduction of evaporation (Sinkeviciene *et al*., 2009), reserve water at the root zone (Khalifa, 1994), increased soil organic matter (Kristina *et al*., 2013), and it is considered as a source of plant nutrients (Hostetler *et al*., 2007). The use of mulches from different sources may increase or decrease the availability of nutrient absorption of roots (Payam *et al*., 2013). Many kinds of mulching are used in production practices. The two major types of mulch are inorganic and organic (Liang *et al*., 2002 and Payam *et al*., 2013). Inorganic mulches include various types of gravel, stone and plastic. (Yuan *et al*., 2009 and Aly *et al*., 2010). Organic mulching uses rice straw, palm leaf, compost, and banana leaves. The present work aimed to study the effect of different mulching materials (organic and inorganic) on the growth and productivity of pomegranate trees (Wonderful cv.).

Material and methods

Field Study

This investigation was carried out during two growing seasons of 2012 and 2013 on four- years old pomegranate trees Wonderful cv., grown on sandy soil at a private orchard at Kilometer 75 from Cairo-Alexandria desert road. The trees were almost uniform in their shape and size. The treatments comprised five mulch material (rice straw (Oryza sativa, L.) at 15 cm. thickness, Palm fronds (Phoenix dactylifera L.) was add in two layers on soil, transparent polyethylene mulch with 50 micron thick, gravel at thickness range from 1.7 to 7 cm and bar soil). All treatments were applied on both sides of the tree row on February until the end of November. The distances between trees are 3 m in the row and 5 m between rows about 280 trees per feddan.

Climate data.

Air temperature and relative humidity

The daily maximum and minimum temperature and relative humidity were recorded by weather station in the Cairo-Alexandria road. The average of 15days for maximum and minimum temperature and relative humidity were recorded.

Soil temperature.

Soil temperature was measured at 10 cm depth at 1 pm. every 15 days from March to end of September under different mulch treatments and bar soil, content.

Soil moisture

Soil moisture was measured by using soil moisture meter model (PMS-714). Measurement range: 0 % to 50 % moisture content of soil sample with 0.1 % resolution at 10 cm depth at time of 1 pm. every 15 day from March to end of September under different mulch treatments and bar soil.

Soil properties

The soil physical and chemical properties data were tabulated in Tables (1 & 2).

TABLE 1. The physical properties of the soil experiment analyzed before treatment.

Depth cm	Sand %	Clay%	Silt %	Texture	Sp %
0-30 cm	97.8	1.0	1.2	sandy	23

TABLE 2. The chemical properties of the soil experiment analyzed before treatment.

Depth Cm	pH	ECe dS/m	Cations meq / l				Anionsmeq / l				SAR
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	CO_3^{--}	HCO_3^{-}	SO_4^{--}	
0-30	8.17	0.65	3.0	1.2	2.0	0.3	2.0	0.0	2.4	2.1	1.4

Growth performance

In each study season, twenty shoots of one-year sprout were tagged randomly at different sides of the trees to determine the number of leaves, shoot length and the number of internodes.

Flowering and yield

The date of flowering was estimated at the beginning of flowering, number of both male, hermaphrodite flowers were counted at the ballon stage and fruit setting percentage were recorded per tree on the twenty tagged shoots. Final fruit set were counted and yield consequently calculated as average fruit weight was multiplied by the number of the resulted fruit in both of the study seasons.

Physical Characteristics of the fruit

Three replicates of fruits, each one contain five fruits, were used to determine fruit physical characteristics by recording fruit weight, fruit volume, fruit length, fruit diameter and shape index. Selected fruits were peeled by hand in the laboratory, then, their rind was separately and weighted, thus calculating the aril (edible part) weight/fruit.

Fruit chemical properties

Total soluble solids (T.S.S%) was measured by a hand refractometer. Acidity of fruit juice was determined by titration with 0.1 normal sodium hydroxide with phenolphthalein as an indicator, according to A.O.A.C. (1985), then, T.S.S./acid ratio was calculated. Total sugar percentage was determined according to the method described by Dubois *et al*. (1956). Vitamin C content (mg.) was determined according to A.O.A.C. (1985). Total anthocyanin (mg/100 ml.) content in fruit juice and rind were measured as described by Hsia *et al*. (1965). Tannins content was determined in fruit juice by the method described by Winton and Winton (1945).

Aril mineral composition

A sample of 10 fruits of each treatment was randomly selected , washed and peeled by hand separately, their aril (edible part), dried at 70 °C till constant weight and grounded for the determination of the following nutrient elements:

Nitrogen: was determined by the modified Micro-Kjeldahl methods as outlined by (Pregl, 1945).

Phosphorous: was estimated by the method described by Murphy and Riley (1962).

Potassium: was determined by flame-photometer according to Chapman and Pratt (1961).

Calcium: was Spectrophoto Metrically determined using Atomic Absorption (Model, Spectronic 21 D) as described by Jackson (1973). The concentration of N, P, K and Ca were expressed as percent per dry weight.

Economic evaluation

Economic evaluation was calculated according to Heady and Dillon (1961)as follows:

- Total gross income = total yield (kg) × 4 L.E.
- Gross margin= total gross income-total cost.
- Benefit/cost ratio = total gross income/ total cost.

Statistical analysis

The experiment was designed in complete randomized blocks with three replicates, each replicate contains three trees. Treatment means were compared according to means in all Duncan's Multiple Range Test at 0.5 level of probability (Duncan, 1955).

Results and Discussions

Air temperature and Relative humidity

Figure 1 shows that the highest maximum temperature was, found in August (about 36 °C), and the lowest maximum temperature was found in March (about 21°C). The minimum air temperature was higher in August (about 26°C) and the lowest minimum air temperature was found in March (about 11°C). Figure 2 shows maximum and minimum relative humidity during growth season. The

highest maximum relative humidity was found in June (about 84 %) and the lowest was found in April (about 16 %).

Hot and dry climate during pomegranate fruit development improves fruit quality. The pomegranate was affected if the temperature remains below 11°C for a longer time. Humid climate during fruit setting adversely affects fruit color development, quality and increases pest and disease attack (Hess-Pierce and Kader, 2003).

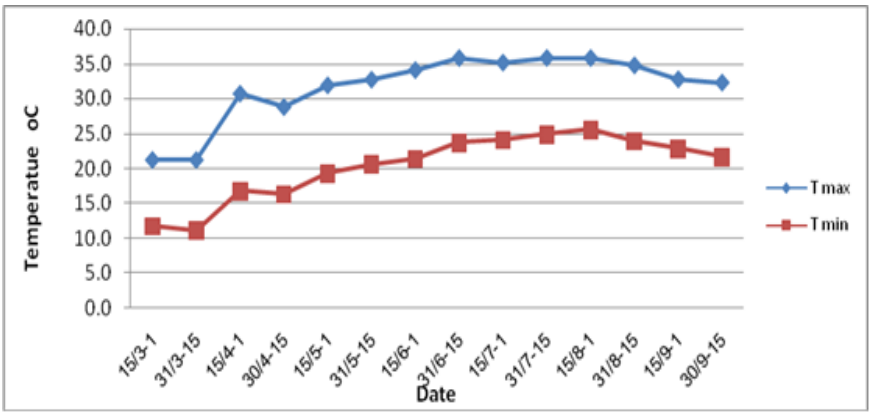

Fig. 1. Maximum and minimum air temperature in Alex. desert road area, average of two years (2012 and 2013).

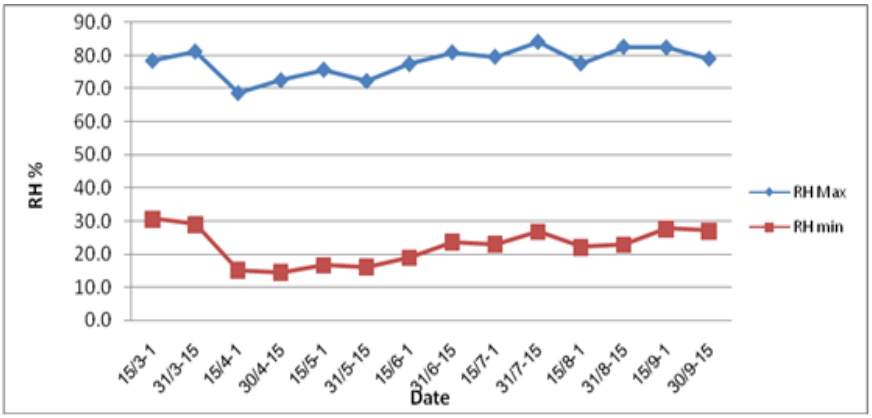

Fig. 2. Maximum and minimum Relative Humidity in Alex. desert road area, average of two years (2012 and 2013).

Soil temperature

Average soil temperature at 10cm depth under different mulch marital from March to September was shown in Fig. 3. During the crop cycle, the highest soil

temperature was found under the transparent mulch (PE) followed by gravel. At the same period, soil temperature under bare soil was lower than under the transparent plastic by 2-3°C. The difference in soil temperature between gravel and bare soil was about 1.8-2.5°C. The rice straw increased soil temperature than bare soil ranged from 1.2 to 2.1°C. The nearest soil temperature to the bare soil was found in Palm fronds with difference about 0.9 - 1.3°C.

Anikwe *et al*. (2007) observed that the unmulched plots had the lowest soil temperature (about 1-3.80°C lower) at different times since planting compared to plastic film mulched plots. Among different mulching techniques plastic film mulching increases soil surface temperature by influencing the heat balance and thus increased the soil temperature and it positively influenced the crop emergence (Aniekwe *et al*., 2004).

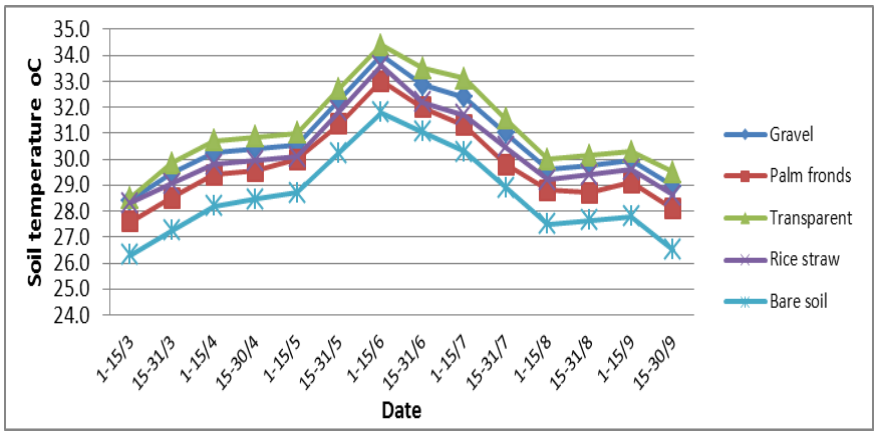

Fig. 3. Soil temperature under different mulch materials in Alex. Desert road farm, average of two years (2012 and 2013).

Soil moisture

Average soil moisture at 15cm depth under different mulch marital from March to September was presented in Fig. 4. The highest soil moisture was found under gravel mulch followed by transparent mulch. The average soil moisture under bar soil was the lowest one about15.9 % while the highest average soil moisture was found under gravel about 29.2% followed by transparent mulch about 25% and 22.4 % under Rice straw mulch.

The higher soil water content in the mulch treated soils was due to a combination of reduced evaporation loss and greater soil water conservation because of reduced weed growth. A common practice today in modern pomegranate orchards is to use mulches. Such mulches conserve soil moisture, reducing water consumption by 20% to 25% and significantly reduce weed population by 20% to26% as compared to controls (Aulakh & Sur 1999, Chan *el al* ., 2010 and Ravid *et al*., 2004).

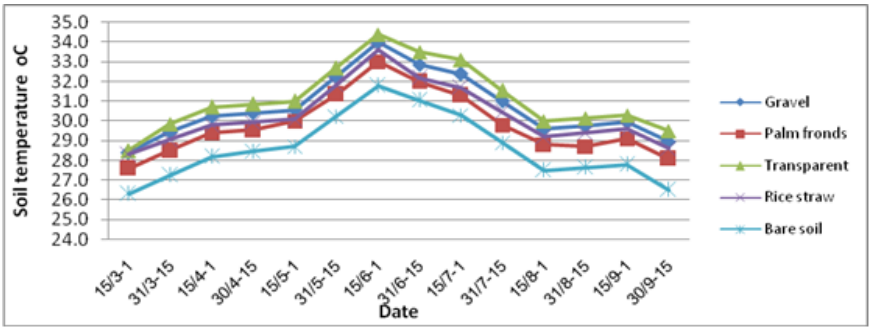

Fig. 4. Soil moisture under different mulch material in Alex. Desert road farm, average of two years (2012 and 2013).

Soil properties after treatment

Table 3 shows that soil organic matter was affected by different types of mulches. The highest soil organic matter was observed in rice straw (2.40%) followed by palm fronds (2.00%). Mulching can contribute to such a development by improving organic matter content in the soils and by affecting other soil characteristics (Ferrini *et al.*, 2008). Covering the soil with different type of mulches improve environmental conditions for soil organic matter via, preventing of water and wind erosion, inhibiting drastic variation in humidity and temperature (Jodaugiene *et al.*, 2010).

Soil available phosphorus was affected by different types of mulch. The highest soil available phosphorus was observed in rice straw (2.75 kg /100 g) followed by palm fronds (2.60 kg /100 g).These findings are in close conformity with tendency of a higher amount of available phosphorus in the soil in mulched plots was determined by Sinkeviciene *et al.*, (2009).

Soil available potassium was also affected by different types of mulch. The highest soil available potassium was observed in soil covered with rice straw (45 kg /100 g) followed by palm fronds (43 kg /100 g) and the lowest was observed without mulch treatment (26 kg/100 g). Organic mulches probably have much more potassium in their structure and regulation of soil temperature and moisture which helped increase soil available potassium by Vijay (2014).

TABLE 3. Evaluation of main properties of soil after 2-years from treatment.

Treatment	*OM	P	K
	(%)	kg /100 g	
Control	1.80	2.50	26
Rice straw	2.40	2.75	45
Palm frands	2.00	2.60	43
Transparent	1.80	1.70	34
Gravel	1.80	1.73	35

* OM = organic matter.

Effect of mulching on some vegetative growth aspects:

Number of leaves /shoot

Data presented in Table 4 shows that number of leaves/twig in gravel mulch applications were (54.10 & 74.07) if compared with control (31.10 & 37.83) during both seasons. Yamanaka *et al*. (2004) stated that the evaporation processes under gravel mulches were much more stable. Pang *et al*. (2012) showed that the soil moisture and microbial quantity increased when mulched by gravel and sand. Hence, this could increase nutrients uptake and translocation of nutrients. Many investigators supported these findings (Belatus, 2002). In addition to that, Moslem *et al*. (2012) reported that, all treatments of mulching significantly increased the number of leaves of fig trees compared with control.

Shoot length and number of internodes

The effect of mulching on shoot growth and internodes of pomegranate wonderful cultivar is presented in Table 4, it is obvious, that shoot growth parameters (length and number of internodes) significantly influenced by the treatments.

The highest shoot length was recorded with gravel mulch treatment (32.83 & 37.62 cm) during the two seasons. As for internodes, gravel also was the superior in both seasons (14.67 & 18.23cm) if compared with the control. The obtained data show that gravel acts an activation which increased shoot length and number of internodes. Zhang *et al*. (2010), reported that soil moisture content in apple trees zone was the highest with gravel mulch treatment. This could be possible due to increase intensive metabolic processes (Lei *et al*., 2012).

The above mentioned are in harmony with those of Verma *et al*. (2005), who reported that mulching improved vegetative growth of apple trees and distribution of roots and their absorption of nutrients.

TABLE 4. Effect of mulching on some morphological properties of wonderful cv. pomegranate trees /branch /meter during 2012 and 2013 seasons.

Treat	No. of leaves/ shoot		Shoot length (cm)		No. of internodes	
	2012	2013	2012	2013	2012	2013
Control	31.10CD	37.83C	21.63BC	22.47D	10.77C	11.73D
Rice straw	33.67BC	46.23B	23.07B	26.83B	12.67B	14.67B
Palm frands	28.67D	34.33C	20.73C	22.60D	11.00C	13.13C
Transparent	36.80B	48.43B	21.60BC	25.07C	11.33C	13.67BC
Gravel	54.10A	74.07A	32.83A	37.62A	14.67A	18.23A

Values within column having different letters showed statistically significant differences ($p < 0.05$) .

Effect of mulching on flowering characteristics and fruit set percentage

Data presented in Table 5 illustrate the effect of tested treatments on flowering characteristics as, total male flowers, total hermaphrodite, number of total flowers/twig and sex ratio of wonderful cv. pomegranate trees. The

obtained show that the control treatment had the highest male flowers (45.33 & 48.67) meanwhile the lowest values of total male flowers /twig were recorded for rice straw mulch application (32.76 & 35.07) in the first and second seasons, respectively. Regarding the highest number of hermaphrodite flowers/twig were observed with transparent polyethylene mulch treatment (48.0) in the first season and gravel (48.33) in the second season, respectively. Concerning the number of total flowers/twig, control treatments recorded the maximum number of total flowers/twig (86.33) in the first season and transparent (86.13) in the second season, respectively. The highest sex ratios were recorded with transparent polyethylene mulch treatments in the first season seasons (57.24) and for gravel mulch (56.08) in the second season compared to the control in both season, respectively. As regarding the effect of used mulching treatments on fruit set percentage, data showed the highest values (64.33%) for the application transparent polyethylene mulch in the first season and for rice straw mulch (65.50%) in the second one. the least values (46.20 & 48.40%) are resulted from the control treatment in both seasons, respectively. These results in general are in agreement with those of (Liu *et al*., 2014) on citrus. Improving soil characteristics using mulching increased water uptake by regulating the stoma and preventing excessive water loss through transpiration. In addition, soil mulching with plastic film results in reducing water loss and regulating soil temperature, which has been widely used in agriculture (Zhang *et al*., 2010). However, other reported that soil temperature has a dominant influence on plant growth (Willis and Power, 1975). They all suggested that, higher moisture and temperature and better nutrient availability, through the reduction of leaching offered by mulching, may be the reason for the increase in fruit physical properties (Aly *et al*., 2010) on Anna apple trees.

TABLE 5. Effect of mulching on flowering characteristics and fruit set percentage of Wonderful cv. Pomegranate trees during 2012 and 2013 seasons.

Treat	Total male flowers/twig.		Total hermaphrodite / twig		T. flowers / twig		Sex ratio		Fruit set (%)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Control	45.33 A	48.67 A	44.00A B	36.93 B	86.33 A	85.60 A	50.99 B	43.16 C	46.20 C	48.40 C
Rice straw	32.67 C	35.07 B	38.10 C	34.50 C	67.57 C	69.60 B	56.68 A	49.49 B	63.63 A	65.50 A
Palm frands	34.33 C	38.33 B	43.00 B	44.87 A	77.33 B	83.20 A	55.62 A	53.92 A	48.83 C	50.20 C
Transparent	37.00 BC	38.33 B	48.00 A	47.80 A	74.00 BC	86.13 A	57.24 A	55.44 A	64.33 A	65.13 A
Gravel	40.33 B	37.33 B	40.33 BC	48.33 A	80.67 AB	85.67 A	49.84 B	56.08 A	52.67 B	56.73 B

Values within column having different letters showed statistically significant differences ($p < 0.05$).

Effect of mulching on fruit physical properties

Fruit length, diameter, shape index

The effect of tested treatments on fruit length, diameter and shape index of wonderful cv. pomegranate trees presented in Table 6. The obtained indicated that all mulching used treatments significantly increased the values of fruit length and diameter in both seasons. In this respect, gravel mulch treatment gave higher values of fruit length (9.20 & 10 cm) and fruit diameter (10.00 & 11 cm) in the first and second seasons, respectively. The least values of fruit length (8.20 and 8.33 cm) and fruit diameter (8.33 and 8.93) were obtained for untreated tree in the both seasons, respectively. As regarding fruit shape index, the control treatment had the highest values meanwhile the least values recorded for other mulching treatments and the differences between them were not significant in both seasons. Hence, this indicates that gravel mulch may play an important role in promoting and enhancing physiological processes, uptake and root activation due to the mechanism of evaporation restriction. Gravel mulches may be breaking the continuity of capillary force preventing the movement of liquid water in the macro pores among gravel. Due to this, soil water vaporizes at the soil surface and diffuses through the macro pores amongst the gravels into the atmosphere in the form of vapor (Yuan *et al*., 2009). The obtained results are in accordance with those reported by (Liang, 2002), (Payam, *et al*., 2013) and recently by (Vijay, 2014).

Fruit volume, juice volume and rind thickness

Data presented in Table 6 revealed that the values of fruit volume, juice volume and rind thickness were significantly increased with application of used mulching treatments. As fruit volume, gravel mulch is much better whereas that treatment had the highest values of these characters (627.3 & 679.0 cm^3) for fruit volume, (161.7 and 146.7 cm^3) for juice volume and (0.78 and 0.73cm) for rind thickness during both seasons, respectively. Control treatment gave the last values in this respect. These results emphasize that gravel mulch treatment has a pertinent role on fruit quality. With respect to the effect of rice straw on rind thickness, this kind of mulch material can be explained by release nutrients and provide other special effects (Liang, *et al*., 2002), reported that organic mulch material can be decomposed to release nutrient and provided other special effect. Khorsandi (2011) reported that gravel mulch increases infiltration of water and soil moisture storage. This could be possible due to increase the nutrients uptake. Moreover, mulching plays an important role in the development of potassium-deficiency (Aly *et al*., 2010).

Aril fruit weight, 100 aril weight, and aril weight ratio

Data presented in Table 6 revealed that a significant response of the tested mulches treatments on aril weight fruit, 100 aril weight and aril weight ratio of wonderful pomegranate trees. Gravel mulch treatment gave the highest values of aril fruits weight (255.0 & 270.0g) and highest values of 100-aril weight (40.33 and 43.26g) in the first and second season, respectively. Control treatment gave the lowest values in this respect. Concerning aril fruit weight ratio, results cleared that the application of rice straw was the superior treatment (0.56 & 0.54) during the two studied seasons, respectively.

TABLE 6. Effect of mulches on fruit physical properties of Wonderful cv. pomegranate trees during 2012 and 2013 seasons.

Treat	Fruit length (cm)		Fruit diameter (cm)		F. shape index	
	2012	2013	2012	2013	2012	2013
Control	8.20C	8.33D	8.33D	8.93D	1.05A	1.03A
Rice straw	8.23C	9.50B	9.50B	10.0C	0.87B	0.88B
Palm frands	8.30C	9.33BC	9.33BC	10.40B	0.88B	0.88B
Transparent	8.57B	9.23C	9.23C	10.27BC	0.89B	0.88B
Gravel	9.20A	10.00A	10.00A	11.00A	0.92B	0.86B
Treat	**Fruit volume(cm^3)**		**Juice volume (cm^3)**		**Rind thickness (cm)**	
	2012	**2013**	**2012**	**2013**	**2012**	**2013**
Control	388.2D	400.9D	110.0D	73.33E	0.70AB	0.67B
Rice straw	457.3C	513.3C	155.3B	99.33D	0.74AB	0.73A
Palm frands	516.7B	566.7B	159.7A	134.3C	0.67B	0.70AB
Transparent	520.7B	549.3B	149.7C	141.7B	0.67B	0.67B
Gravel	627.3A	679.0A	161.7A	146.7A	0.78A	0.73A
Treat	**Aril fruit weight (gm)**		**100 aril weight (gm)**		**Aril/fruit weight ratio**	
	2012	**2013**	**2012**	**2013**	**2012**	**2013**
Control	184.4C	192.0C	35.19B	39.80 B	0.53AB	0.51AB
Rice straw	236.8AB	252.7AB	40.15A	41.52 AB	0.56A	0.54A
Palm frands	225.3B	246.6B	38.78A	40.52B	0.47C	0.45BC
Transparent	238.0AB	244.5B	35.27B	40.04B	0.49BC	0.45BC
Gravel	255.0A	270.8A	40.33A	43.26A	0.44C	0.41C

Values within column having different letters showed statistically significant differences ($p < 0.05$).

Effect of mulching on fruit chemical properties

Total soluble solids, acidity, T.S.S / acid ratio and vitamin C.

Data presented in Table 7 showed a significant effect of used different mulches on total soluble solids, total acidity, T.S.S/acid and Vitamin C. For T.S.S., it is obvious that rice straw mulch was the superior in the first and second seasons (15.67 & 16.43 %) followed by palm fronds mulch in the first season (15.63 %) and gravel mulch in the second season (15.88%). These results coincided with Vijar (2014). Moreover, Green and Rakow (1995) who reported that organic mulches probably have much more potassium in their structure and with the regulation of soil temperature and moisture they helped to increasing soil available potassium. Also, Rakow (1989) confirmed that the use of mulches with different sources may increase or decrease the ability of root nutrients to absorb. This emphasized that potassium has an important role in promoting and enhancing the physiological processes (Al-Taweel, 2001). Also, De *et al*. (2005) mentioned that, Banana leaves increased soil moisture contents at varying degrees.

Regarding total acidity, the highest percentage of acidity is recorded with untreated control (1.98 and1.80 %) in the first and second seasons, respectively.

Meanwhile the lowest values (1.79 and 1.69%) were obtained from rice straw mulch treatment in the first and second seasons, respectively. Concerning the T.S.S./acid ratio, the results revealed that rice straw mulch treatment had higher values (8.75 and 9.72), on the other hand the lowest values recorded for control treatment (7.54 and 8.34) in the first and second seasons, respectively. As for vitamin C, the more effective treatment was the rice straw mulch (14.55 and 13.82) while untreated trees gave the lowest values (12.57 and 12.45) in the first and second seasons, respectively. The ripe fruit which had a low acid content, titratable acidity reduction can be used as a standard criterion to detect maturation (Mehdi *et al*., 2011). The maturity index (T.S.S./acid ratio) also appeared to be a good indicator of fruit maturity. The effects of mulching tend to slightly reduce total acidity and therefore the ratio of T.S.S./acid increased in the fruit juice of the treated trees than the control. These findings were agreed with reported by (Meiyan *et al*., 2009 and Zarei *et al*., 2011). In addition, this emphasize that K. output of rice straw treatment has a pertinent role on fruit quality of Kadota fig Cultivar (Adel and Ahmed, 2011).

Total sugars, tannins, total rind and juice anthocyanin

The effect of mulch treatments on total sugars (mg/100 ml), tannins (mg/100 ml), total juice (mg/100 ml) and total rind anthocyanin (mg/100 ml) of Wonderful cv. pomegranate trees are shown in Table 7. The results revealed that, the highest values of total sugars was obtained from transparent mulch (13.40) followed by palm fronds (13.35), rice straw (13.07) and gravel mulch (13.03) in the first season. While gravel mulch, gave the highest (13.88) in the second season followed by transparent (13.03). These results may be due to mulching plays an important role in the development of potassium–deficiency (Aly *et al*., 2010). Concerning, tannins (mg/100m), From the data presented in Table (7), it is clear that tannins recorded the highest values with the control treatment (2.68 & 2.64),while transparent mulch recorded the lowest values (2.40 & 2.20) in the first and second seasons, respectively.

As for total rind and juice anthocyanin (mg/100 g) rice straw mulch treatment gave significantly the highest values (0.71 & 0.84 mg/100g) and (1.42 & 1.52 mg/100g) during both seasons, respectively. The lowest values resulted from the control treatment. This is probably due to the fact that Tannins are metabolites, which defend plants from herbivores by protein precipitation (Zarei *et al*., 2011). On other hand, rice straw mulch found to positively impact citrus fruit yield in extreme weather conditions (Liu *et al*., 2014). This may be due to the improvement of soil characteristics and nutrient status and its important role in translocation compounds which increase fruit quality(Ramalan and Nwokeocha, 2000).

TABLE 7. Effect of mulching on fruit chemical properties of Wonderful cv. Pomegranate trees during 2012 and 2013 seasons.

Treat	TSS (%)		Acidity (%)		TSS/acid		Vitamin (C) mg ascorbic acid/100 ml juice	
	2012	2013	2012	2013	2012	2013	2012	2013
Control	14.93B	15.12C	1.98A	1.80A	7.54C	8.34C	12.57D	12.45E
Rice straw	15.67A	16.43A	1.79C	1.69B	8.75A	9.72A	14.55A	13.82A
Palm frands	15.63A	15.70B	1.87B	1.78A	8.36A	8.82B	13.55B	13.10C
Transparent	15.10B	15.80B	1.90C	1.75AB	7.95B	9.03B	13.90B	13.47B
Gravel	15.20B	15.88B	1.93AB	1.70B	7.94B	9.34A	13.0C	12.79D
Treat	**T. sugars (%)**		**Tannins (%)**		**Total rind anthocyanin (mg/100g)**		**Total juice anthocyanin (mg/100g)**	
	2012	2013	2012	2013	2012	2013	2012	2013
Control	11.95B	12.13C	2.68A	2.64 A	0.31B	0.43C	0.84D	0.90D
Rice straw	13.07A	12.97B	2.43B	2.21C	0.71A	0.84A	1.42A	1.52A
Palm frands	13.35A	12.90B	2.45B	2.23 C	0.65A	0.65B	1.12C	1.25C
Transparent	13.4A	13.03B	2.40B	2.20C	0.66A	0.71B	1.10C	1.33B
Gravel	13.03A	13.88A	2.50B	2.32B	0.67A	0.67B	1.29B	1.39B

Values within column having different letters showed statistically significant differences ($p < 0.05$).

Effect of mulching on fruiting and yield

Data presented in Table 8 revealed that the tested treatments significantly increased average fruit weight , total number of fruits/tree and yield (Kg/tree) of Wonderful cv. pomegranate trees as compared with control during both seasons. In this concern, application of gravel mulch treatment presented heaviest fruit weight (575.2 & 609.8 g) followed by rice straw mulch (557.1 & 556.8g) while control treatment had the lowest weight (375.8 and 381.9 g) in the first and second seasons, respectively. The other treatment were in between. As for total number of fruits/tree, gravel mulch was the highest values (57.33 & 64.33) on the other hand, the least values resulted from control treatment (44.0 & 42.67) in both seasons, respectively. Concerning yield (Kg/tree) the results in Table (8) revealed that all mulching materials applied had a pronounced increase of yield. The effect was higher with application of gravel mulch (32.98 & 39.23) followed by rice straw mulch (30.27 & 34.15 Kg) while the least values are resulted from control (16.54 & 16.30Kg) during both seasons, respectively. The present data are in accordance with many previous works like (Adel and Ahmed 2001), (Aly *et al*., 2010), and (Liu *et al*., 2014).

TABLE 8. Effect of mulching on fruiting and yield of wonderful cv. pomegranate trees during 2012 and 2013 seasons.

Treat	Av. Fruit weight (g.)		Total No. of fruits/tree		Yield/tree (Kg.)	
	2012	2013	2012	2013	2012	2013
Control	375.8D	381.9D	44.00B	42.67C	16.54D	16.30E
Rice straw	557.1A	556.8B	54.33A	61.33A	30.27A	34.15B
Palm frands	481.8B	539.2B	54.67A	53.33B	26.34B	28.76C
Transparent	431.6C	476.0C	54.33A	49.33B	23.45C	23.48D
Gravel	575.2A	609.8A	57.33A	64.33A	32.98A	39.23A

Values within column having different letters showed statistically significant differences ($p < 0.05$).

Effect of mulching on sunburn and cracked fruits percentage

Data presented in Table 9 shows that transparent mulch application, had an obvious increase in sunburn (6.67% & 9.67%) followed by control treatment (5.33% & 4.67%) during both seasons, respectively. The least values are recorded with the application of rice straw (3.33 and 2.67%) in the first and second seasons respectively. Concerning cracked fruits, Table (9) showed that the application of gravel and rice straw treatments gave the least values compared to other treatments. This may be due to the role of rice straw and gravel mulch applications in promoting and enhancing the metabolic process and regulate water balance (Yajun *et al*., 2011 and Liu *et al*., 2014) who confirmed that the effect of straw mulching on Citrus fruit yield could be positive in extreme weather condition. Gravel mulch also prevents soil surface from being directly exposed to solar radiation, which prevents the reduction of surface soil water vaporization and in heat energy absorption (Yuan *et al*., 2009).

TABLE 9. Effect of mulching treatments on fruit sunburn and cracks during 2012 and 2013 seasons.

Treat	Sun burnt fruits (%)		Cracked fruits (%)	
	2012	2013	2012	2013
Control	5.33A	4.67B	1.67A	1.00A
Rice straw	3.33B	2.67D	0.00C	0.00C
Palm frands	3.33B	4.33BC	1.00B	0.67B
Transparent	6.67A	9.67A	1.33AB	1.00A
Gravel	3.33B	3.00CD	0.00C	0.00C

Values within column having different letters showed statistically significant differences ($p < 0.05$).

10. Effect of mulching on aril content of nitrogen, phosphorus, potassium and calcium (%)

The obtained results presented in Table (10) revealed that transparent polyethylene treatment resulted in a high Nitrogen values (1.84, 1.93%) followed by palm fronds (1.81, 1.89%), with control treatment as the least (1.21, 1.22%)

during the two seasons, respectively. Antonious *et al*. (1996) reported that transparent polyethylene mulch reflected the largest amount of blue light. In addition, Decoteau *et al*. (1988) believed that shorter and more auxiliary growth could result from blue light reflected by transparent polyethylene mulch. Liang *et al*. (2002) reported that palm fronds mulch can be decomposed to release nutrients and provide other special effects.

Phosphorus content during the two seasons was affected by gravel mulch treatment as significant increase in phosphorus contents (0.61, 0.64) was observed during the two seasons of the study, respectively. Thus could be due to the increase of soil moisture and the soil microbial quantity when mulched by gravel and sand (Lei *et al*., 2012). Microorganisms in the soil play a vital role in nutrients cycling and mediate various processes through interactions with plants and other soil organisms (Zarb *et al*., 1999).

Regarding the effect of mulch material on aril potassium content, data presented in Table (10) indicated that Palm fronds mulch application gave the highest values of potassium content (1.27%) in the first season, whereas rice straw gave the highest (1.31%) in the second season. As for the control treatment, it gave the lowest values of k content (1.07, 1.01%) at the both season, respectively.

Vijay (2014) found that organic mulches probably have much more potassium in their structure and with the regulation of soil temperature and moisture they helped in increasing soil available potassium. Finally, using of different mulches lead to the increase in N. P. K., and, Ca contents in the aril mineral composition (Aly *et al*., 2010).

Calcium content in the aril mineral composition has been affected by the used mulching application. (Table 10) a significant increase in calcium content with application of rice straw mulch (1.19%) in the first season and with palm fronds in the second one (1.25%). It could be concluded from the obtained results that organic mulches eventually breaks down and becomes a part of the soil and a source of plant nutrients (Sharma *et al*., 1998).

TABLE 10. Aril mineral composition of the studied Wonderful cv. pomegranate during 2012 and 2013 seasons.

Treat	N (%)		P (%)		K (%)		Ca (%)	
	2012	2013	2012	2013	2012	2013	2012	2013
Control	1.21D	1.22E	0.33E	0.36E	1.07D	1.01E	1.05D	1.10E
Rice straw	1.46C	1.55D	0.55B	0.59B	1.22B	1.31A	1.19A	1.22B
Palm fronds	1.81A	1.89B	0.49C	0.51C	1.27A	1.25B	1.16B	1.25A
Transparent	1.84A	1.93A	0.40D	0.42D	1.01E	1.11D	1.17B	1.20C
Gravel	1.65B	1.69C	0.61A	0.64A	1.16C	1.23C	1.11C	1.18D

Values within column having different letters showed statistically significant differences ($p < 0.05$).

Effect of mulches on dry cut grass weight

Results presented in Table 11 shows that application of mulching should be recommended for the control of weeds. Existing weeds are Ipomoea L., characterized as naturalized in sandy places (Tackholm, 1974). All mulching treatments showed a clear effect on weeds in pomegranate orchards. Bare soil gave the highest values of cut grass weight (74.89 & 80.75gm) respectively in both seasons. Mulching with rice straw, palm fronds residues, transparent polyethylene and gravel found to be a good practice for controlling weeds in pomegranate orchards could be used effectively for controlling weeds in pomegranate orchards. The efficiency of mulching in controlling weeds also has benefits on soil environment. (Handa, 1991). These results are in line with those obtained by Abo El-Wafa *et al*. (2012), Adel & Ahmed (2011) and Amini & Morteza (2013). In addition, Paolo *et al*. (2011) reported that several studies had shown that full season competition due to unmanaged weeds could cause reduction in yield of up to 37%.

TABLE 11. Effect of some mulching materials on cut grass weight (g) during 2012 and 2013 seasons.

Treat	Dry cut grass weight(g)	
	2012	2013
Control	74.89A	80.75A
Rice straw	0.00B	0.00B
Palm fronds	0.00B	0.00B
Transparent	0.00B	0.00B
Gravel	0.00B	0.00B

Values within column having different letters showed statistically significant differences ($p < 0.05$).

Economic evaluation

Data presented in Table 12 shows the net benefit of the effect of different mulching treatments on pomegranate trees during 2012 and 2013 seasons. Mulching with gravel gave the highest benefit cost ratio (10.0 &12.8) during both seasons, respectively. It means that everyone Egyptian pound spent on gravel treatment result in gross income of (10.0 &12.8) in years 2012 and 2013, respectively. In addition, gravel treatment gave the highest gross margin (16566 & 21786 L.E.) during both seasons.

TABLE 12. Economic evaluation of the effect of some mulching material treatments on Winderful cv. pomegranate trees during 2012 and 2013.

Treatments	Mean yield kg/fed		Increase of yield kg/fed		Gross income per treatment L.E./fed.		Total costs per treatment L.E./fed.		Gross margin L.E./fed.		Benefit cost ratio	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Control	4631	4564	0	0	0	0	0	0	0	0	0	0
Rice straw	6566	7109	1935	2545	7739.2	10180.8	815	842	6924.2	9338.8	9.5	12.1
Palm frond	7330	7692	2699	3128	10796.8	12510.4	2552	2894	8244.8	9616.4	4.2	4.3
Transparen	8529	9713	3898	5149	15590.4	20596.8	3236	3578	12354.4	7018.8	4.8	5.8
Gravel	9234	10472	4603	5908	18412.8	23632	1846	1846	16566.8	21786	10.0	12.8

Conclusion

According to the obtained results and discussions above, we can conclude the following:

- Soil temperature and soil moisture were greater than bare soil in case of using mulch.
- The fruit yield increased under mulch compared with bare soil.
- The application of mulch was effective in weed management in the farm.
- The Gravel mulch is recommended to obtain high production and best quality of pomegranate.
- Economically, gravel gave the highest benefit cost ratio.
- The mulch technique is considered effective method for climate change adaptation.

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التغطية الآثار على الإنتاجية وجودة ثمار الرمان المنزرعة فى التربة الرملية

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تمت الدراسة خلال موسمي ٢٠١٢ و ٢٠١٣ على أشجار رمان عمر أربعة سنوات صنف وندرفول النامى فى تربة رملية تحت ظروف الرى بالتنقيط لتقييم أربعة معاملات لتغطية سطح التربة. وقد كانت معاملات التغطية هى : قش الأرز ، وسعف النخيل ، البلاستيك شفاف و الزلط لدراسة تأثير ذلك على نمو وإنتاجية أشجار الرمان. وقد تم تصميم احصائى للتجربة في قطاعات كاملة العشوائية ضمت ثلاثة مكررات لكل معاملة. وقد أشارت النتائج إلى أن معاملة الزلط تفوقت في عدد الأوراق وطول الفرع وعدد السلاميات وأيضا طول وقطرة وحجم ووزن الثمرة وكذلك وزن الحبة داخلها والمحصول الكلى. بينما معاملة قش الأرز أعطت أعلى نسبة في المواد الصلبة الذائبة وكذلك فيتامين ج و محتوى الانثوسيانين فى كل من القشرة والعصير. وقد انخفض تشقق الثمار والإصابة بأشعة الشمس فى كل من معاملتى الزلط والقش. وقد أدت معاملات تغطية سطح التربة الى تقليل الحشائش وزيادة رطوبة وحرارة التربة وخاصة فى معاملة الزلط عن الكنترول. وبناء على ما سبق يمكن التوصية باستخدام الزلط لتغطية سطح التربة لتحسين رطوبة التربة ونمو وجودة وإنتاجية أشجار الرمان.

الكلمات الدالة : الرمان صنف وندرفول - ملش قش الأرز - ملش سعف النخيل - ملش البلاستيك الشفاف - ملش الزلط - رطوبة التربة - حرارة التربة.