Scientific Journal of Agricultural Sciences

Print (ISSN 2535-1796) / Online (ISSN 2535-180X)

Water Conservation and Productivity Improvement of "Le Conte" Pear Trees Utilizing a Partial Root-Zone Drying Technique Combined with Anti-Transpiration Materials and Polyethylene Mulch

Abdel-Mohsen, M.A.

Pomology Department, Faculty of Agriculture, Cairo University, Giza, Egypt.

Citation: Abdel-Mohsen, M.A. (2023). Water Conservation and Productivity Improvement of "Le Conte" Pear Trees Utilizing a Partial Root-Zone Drying Technique Combined with Anti-Transpiration Materials and Polyethylene Mulch. Scientific Journal of Agricultural Sciences, 5 (3): 1-18. https://doi.org/10.21608/sjas.2023.228623.1325

Publisher :
Beni-Suef University, Faculty of Agriculture

Received: 11 / 8 / 2023
Accepted: 1 / 9 / 2023

Corresponding author:
Mohamed Abdel-Mohsen

Email:
mael.shazly@gmail.com, mohamed.abdulmohsen@agr.cu.edu.eg

ABSTRACT

Irrigation water scarcity is a major issue that reduces horticultural crop output and productivity. As a result, efforts must be made to improve irrigation technologies, irrigation management techniques, and the usage of water-saving materials. As a result, the goal of this research is to justify the use of water in irrigating "Le-Conte" pear plants under desert soil conditions while minimizing the negative influence on production and fruit quality. The partial root drying (PRD) technique, as well as anti-transpiration products and plastic mulch, are used to accomplish this aim. During the study seasons, trees were irrigated with PRD technology at levels of 75 or 50 % of the irrigation requirement (IR) without any additives, or with kaolin or green miracle as anti-transpiration, or by covering the soil surface with black polyethylene, as opposed to irrigation with 100 % of the IR by the traditional way.

The results showed that under the drip irrigation system, water can be conservation by reducing irrigation amounts by 25% of the optimal rate using PRD technique, especially when combined with the use of mulching or the use of anti-transpiration materials, it gave superior or similar results to the results achieved with the use of full irrigating rate in the normal way without any additional treatments for studied traits such as total leaf macro nutrient content, total chlorophyll content, carbohydrates, and IAA and GA3 content which achieved the highest yield with the best fruit characteristics in terms of fruit weight and a good percentage of fruits with red cheek.

KEYWORDS: "Le Conte", Pear Trees, Conservation of Water, Partial Drying Technique (PRD), Anti-Transpiration Materials, Plastic Mulch.

1. INTRODUCTION

Drought is just one of many environmental conditions that affect plant growth, production, and quality. Water scarcities mostly affect the growth and productivity of several crops (Tawfik and El-Mouhamady, 2019). Drought reduced production proportionally more than any other abiotic or biotic factor (Bakht et al., 2010 and

Khan et al., 2010) also it has an impact on plants at every stage, encompassing internal functions, processes, physical appearance, and production (Tawfik and Elmohamady 2019).

Agriculture is the largest consumer of available fresh food water and has the capacity to use more water than any other user (Iqbal et al., 2020). Therefore, low-water-use irrigation systems are used to improve water productivity (WP). In this irrigation method, during each watering time, irrigation is applied to only half of the plant's root side, allowing this root part absorbs the water and the other remains dry for the coming watering time. For this reason, the partial root drying (PRD) technique is a mandatory irrigation technique in which one root part is placed in dry soil and the remaining part of the root under irrigated soil conditions (Rashid et al., 2019 and Ahmad et al., 2020). At this time, deficient irrigation (DI) and partial root drying (PRD) techniques are low water consumption strategies that reduce the water requirements of crops from maximum use to extremely low water requirements. The use of these types of technologies is often associated with better growth without any impact on production which ultimately helps to save more water (Ahmadi et al., 2010). Various studies on DI and PRD have shown that when the same water amount was used, PRD produces a greater yield versus DI (Leib et al., 2006; Rashid et al., 2019 and Ahmad et al., 2020).

In addition, drying of soil roots during PRD causes the plant to produce the ABA hormone which is transported due to the influx of water into xylem vessels through buds designed to maintain the shoot function (Kang and Zhang, 2004). As a result of PRD, the plant's root may detect dry soil conditions and induce ABA, resulting in incomplete stomatal closure and limited leaf expansion, while the moist roots absorb a lot of water to keep the plant's shoots hydrated (Iqbal et al., 2019a). Drip irrigation methods have shown greater effect when using PRD on different types of crops such as apple fruit (Leib et al., 2006) and grape (De la Hera et al., 2007) .

Furthermore, the combination of several methods to work to save water with the least negative impact is a good thing. The use of antiperspirants can play a beneficial role in reducing transpiration by preventing excessive water loss into the atmosphere from stomata (Khalil, 2006). Kaolin is a natural mineral, which is a type of transpiration agent. Where is a non-toxic alumino clay mineral; Kaolin spray lowers leaf temperature by enhancing leaf reflectivity and hence lowering plant transpiration rates (Ibrahim and Saleem, 2010). Green miracle is a new type of anti-stress supplement. It's made from an inedible vegetable oil and a long-chain fatty alcohol. Green miracle is mostly based on the theory of light reflection. Spraying it creates a glassy thin surface that reflects incident sunlight more than under normal circumstances. The heating influence of light on plant tissues is therefore avoided (EL-Gioushy et al., 2017).

Using soil coverings (mulch) is another option to save water. Mulch is commonly used to improve the soil surrounding plants and limit the time spent watering and weeding. Mulch helps the soil retain moisture in the summer, discourages weed growth, and protects plant roots in the winter. Plastic mulching provides increased output, earlier crop ripening, higher quality, improved insect management, and weed control, to name a few benefits (Said et al., 1993).

Le- Conte, which is regarded as the primary pear cultivar planted in Egypt, is a hybrid of the European and Asian pears (Quinet and Wesel, 2019). Therefore, the goal of this research is to rationalize the use of water in irrigating "Le-Conte" pear trees under desert soil conditions, taking into consideration minimizing the negative impact on productivity and fruit quality through using a partial root drying technique (PRD) as well as using anti-transpiration materials or using plastic mulch.

2. MATERIALS AND METHODS

2.1. Plant material and growing conditions

The current study was conducted on 10-year-old Le-Conte pear trees and began in 2017 and ran for three consecutive growing seasons. The first season is considered a pre-season to remove remnants traces of previous irrigation practices.

Pear trees were established 5 x 5 m in a private orchard on the Cairo-Alexandria Desert Road orchard (64 km from Cairo) under a drip irrigation system and regularly receive recommended cultivation practices. Solis Laboratory, Water and Environmental Research Institute, provided the chemical analysis of water in Table (1) and the physical/chemical analysis of the experimental soil in Table (2).

Table 1. Water chemical analysis

EC (ds/m)	**PH**	**Anions (mm/L)**			
		CO_3^{-2}	HCO_3^-	Cl	SO_4^{-2}
1.54	7.20	---	1.70	4.88	8.51
Residual sodium carbonates	**Saturated sodium percentage**	**Cations (mm/L)**			
		Ca^{+2}	**Mg^{+2}**	**Na^+**	**K^+**
---	2.84	4.61	4.32	6.00	0.51

Table 2. Chemical and mechanical analysis of the soil sample

Cations (mm/L)				**Anions (mm/L)**				**Saturation percent SP**	**Electrical conductivity EC (ds/m)**	**Salinity (ppm)**	**pH 1:2.5**
K^+	**Na^+**	**Mg^{++}**	**Ca^{++}**	**$SO_4^=$**	**CL**	**HCO_3^-**	**$CO_3^=$**				
0.56	19.8	5.2	8.4	9.7	22.8	1.5	-	21.6	3.4	2304	7.92

Textures	**Volumetric distribution of soil granules (%)**			
	Clay	**Silt**	**Fine sand**	**Coarse sand**
Loamy sand	2.3	11.6	45.6	40.5

2.2.Experiment design

The trees chosen for the study were of typical development, healthy, and uniform in vigor, then treated with nine treatments. Whereas, for each treatment, the selected trees were separated into three replicates and placed in a randomized complete block design. There were four trees in each replicate, plus one guard tree at either end.

The selected trees were irrigated in the three study seasons at levels of 100% by the normal way (control group) of irrigation requirements (IR), in addition to using partial root-zone drying technique (PRD) at levels of 75 or 50% of IR without any additives or as treated with either kaolin or green miracle as an anti-transpiration or by covering the soil surface with black polyethylene under PRD levels.

All irrigation treatments were calculated based on the irrigation requirements (IR). The amount of water was theoretically calculated using meteorological data in the cultivation area. Applied irrigation amounts were calculated as the daily irrigation requirement of the crop (liters/tree/day). Weekly IR is scheduled based on the daily ETo. Using the CROPWAT 8.0, the Penman Monteith technique was utilized to compute the 100 % of ET crop of pear trees in the region throughout the three seasons tested (Smith, 1991). For 100, 75 and 50 % of IR, the average total quantity of water consumed over the year was 25.22, 18.91 and 12.61 m3/tree/year respectively.

In irrigation treatments, with the control treatment, there is an irrigation line on each side of trees row, but with partial irrigation treatments, there are 4 lines for each row, 2 lines on each side of the trees row, and irrigation is exchanged on each side every 5 to 7 days.

From the beginning of May until the end of August, anti-transpiration ingredients such as green miracle or kaolin were sprinkled with a 21-day interval between sprays. Green miracle (80% fatty alcohol and diluent, 10% neutraliser, 5% emulsifier, 5% stabiliser, manufactured by T. Stanes and Company Limited in India) sprayed at a concentration of 0.25 percent. While kaolin is a natural mineral (clay), the major component is kaolin (Al4 Si4 O10 (OH)8), which has the following theoretical composition: SiO_2 = 46.5%, Al_2O_3 = 39.5% and H_2O = 14% (Obaje et al., 2013). Kaolin (made in China by Guangzhou Company) was sprayed at a concentration of 5%. During the three years of the experiment, the mulching was done by covering the soil surface with black polyethylene (50 microns thickness), which was changed at the conclusion of each season.

2.3. Measurments

2.3.1. Mineral composition

Inorganic components were estimated in mid-July of each season, by taking a sample of 30 leaves from middle part of the current shoot growth for each replicate and then the leaves were oven dried at 68 °C for 48 h after being washed with tap water. According to Cottenie (1980), 0.2g of the dried samples was digested using H_2SO_4 and H_2O_2. The extract was used to estimate the macro nutrient concentration. Total N content was determined by using the modified- micro-Kjeldahel method (Jackson, 1973). P was determined by calorimetric method using the chlorostannous reduced molybdophosphoric blue color method according to Jackson (1973). While K was determined using the flame photometer (Model: Jenway PFP7) (Chapman and Pratt, 1961).

2.3.2. Biochemical analysis

In order to estimate chlorophyll, carbohydrates and phenols, the leave samples were taken on July 15. Total chlorophyll was measured spectrophotometrically according to Moran (1982). Total carbohydrates were determined according to the AOAC (1990). While the total phenol content was determined by spectrophotometry using the colorimetric Folin-Ciocalteu method (Singleton and Rossi, 1965).

Additionally, the activities of phyto-hormones and endogenous enzymes were measured in the terminal buds, as well as the first and second young leaves, in mid-July. The quantification of GA3, ABA and IAA were determined according to Fales and Jaouni (1973). The activity of the peroxidase enzymes (PRO) was determined according to Macheix and Quessada (1984) and poly phenol oxidase enzymes (PPO) activity was determined according to Dhindsa et al. (1981).

2.3.3. Yield and fruit characteristics

Fruit set (%), three weeks after full bloom for each tree was determined by tagging four branches in each of the four directions. The branches were as close as practicable in diameter and spur load. The fruit set percent was estimated using the following equation:
Percentage of fruit set (%) = (Number of fruit set/ Total number of flowers)*100.

At fruits maturity stage, a sample of ten fruits was harvested from each considered tree and the physical characteristics were evaluated. Fruit weight (g) was measured using a digital scale and hardness of the fruit (Newton) using a pressure tester .

The yield was calculated by multiplying the average weight of the fruit born on that specific tree taken from the representative sample by the number of fruits born on each tree.
Immediately before harvesting, the sunlight intensity penetrating trees was estimated using a digital Lux meter. The proportion of red-cheek and burnt fruit was visually estimated as the percentage on each tree relative to the total number of fruits on the tree.

2.3.4. Experimental design and statistical analysis

The studies were authorized using the Randomized Complete Block Design. An analysis of variance was performed using the data from the analytical determinations (ANOVA). Duncan's multiple range test was used to make mean comparisons at a 5% level (Snedecor and Cochran, 1989).

3. RESULTS

3.1. Effect of irrigation technique and anti-transpiration materials or mulching on leaf macronutrient content

As for leaf content of nitrogen, phosphorous and potassium, Table (3) showed that using anti-transpiration materials at an irrigation rate of 75%.

Table 3. Leaf N (%), P (%) and K (%) content of "Le Conte" pear trees as influenced by irrigation technique and anti-transpiration materials or mulching during 2018 and 2019 seasons

Treatments	N %		P %		K %	
	2018	2019	2018	2019	2018	2019
PRD at 50% of IR with kaolin	2.00 e	2.10 d	0.16 bc	0.21 a	1.28 d	1.32 e
PRD at 75% of IR with kaolin	2.53 a	2.55 ab	0.12 ab	0.24 a	1.55 a	1.68 ab
PRD at 50% of IR with green miracle	2.16 d	2.11 d	0.21 ab	0.21 a	1.43 bc	1.42 d
PRD at 75% of IR with green miracle	2.55 a	2.58 a	0.23 a	0.25 a	1.59 a	1.72 a
PRD at 50% of IR with mulching	2.25 cd	2.42 bc	0.21 ab	0.22 a	1.48 b	1.56 c
PRD at 75% of IR with mulching	2.44 ab	2.52 ab	0.23 a	0.23 a	1.48 b	1.57 c
PRD at 50% of IR	1.55 f	1.61 e	0.14 c	0.15 b	0.92 e	0.95 f
PRD at 75% of IR	2.38 bc	2.37 c	0.20 ab	0.22 a	1.41 c	1.53 c
Control (100% of IR)	2.56 a	2.51 ab	0.23 a	0.24 a	1.55 a	1.60 bc

PRD: partial root-zone drying technique IR: irrigation requirements
Means having the same letter (s) in each column are insignificantly different.

of IR by PRD technique, showed the significant highest content in the leaves and it was significantly equal to the content of tree leaves irrigated with an irrigation rate of 100% in the normal way, during the two years of study. Also using soil mulch with 75% of IR by PRD technique gave the same results with nitrogen and phosphorous. Contrary, the lowest leaf content of the three nutrients was achieved with irrigation at the lowest rate of 50% and without any additives

3.2. Effect of irrigation technique and anti-transpiration materials or mulching on leaf total chlorophyll, carbohydrates and phenols contents:

The results in Table (4) showed that the highest total chlorophyll in leaves was significantly achieved in the two seasons with the use of PRD at 75% of IR with green miracle treatment only. While in the second season, this was also achieved by PRD at 75% without any additive or with anti-transpiration or soil mulching and also with 100% of IR in the normal way. While the lowest leaf chlorophyll content was recorded with the PRD at 50% of IR without any additives .

The highest content of carbohydrates was achieved with PRD at 75% of the actual irrigation with spraying with either kaolin or green miracle in both seasons of the study. It was also achieved with PRD at 75% and covering the soil with mulch in the first season (Table, 4) .

On the contrary, the highest amount of total phenols was achieved with trees irrigated with the lowest rate PRD at 50% of IR whether alone or with green miracle, and this was also true when using PRD irrigation way at 75% of IR alone without any additions. Whereas, the lowest significant content of total phenols was obtained with irrigation at a rate of 100% of IR by the normal technique or by using anti-transpiration or mulching with an irrigation rate of 75% of IR by the PRD technique or by mulching with PRD at 50% of IR (Table, 4).

3.3. Effect of irrigation technique and anti-transpiration materials or mulching on terminal buds and young leaves phyto-hormones and endogenous enzymes content:

An overall, with the rationalization of water, the use of an anti-transpiration or mulching material under PRD irrigation technique, significantly increased IAA and GA3 hormones (Table, 5). The lowest significant values of the two hormones were achieved with irrigation with PRD at 50% of IR and PRD at 75% of IR without additives, respectively. On the contrary, the highest content

Table 4. Total leaf chlorophyll (mg/g FW), carbohydrates (%) and phenols content (mg GAE/L) of "Le Conte" pear trees as influenced by irrigation technique and anti-transpiration materials or mulching during 2018 and 2019 seasons

Treatments	Total chlorophyll (mg/g FW)		Total carbohydrates (%)		Total phenols (mg GAE/L)	
	2018	2019	2018	2019	2018	2019
PRD at 50% of IR with kaolin	2.08 c	2.01 b	20.15 e	21.39 e	1.67 b	1.60 b
PRD at 75% of IR with kaolin	2.40 b	2.34 a	30.11 a	36.84 ab	1.14 de	1.10 c
PRD at 50% of IR with green miracle	2.08 c	2.03 b	22.26 d	25.08 d	2.47 a	2.38 a
PRD at 75% of IR with green miracle	2.52 a	2.40 a	30.12 a	38.91 a	1.11e	1.07 c
PRD at 50% of IR with mulching	2.11 c	2.02 b	28.74 ab	34.89 b	1.23 cd	1.18 c
PRD at 75% of IR with mulching	2.40 b	2.38 a	28.44 b	35.22 b	1.24 c	1.10 c
PRD at 50% of IR	1.92 d	1.78 c	19.26 e	20.42 e	2.48 a	2.47 a
PRD at 75% of IR	2.31 b	2.27 a	28.30 b	30.26 c	2.46 a	2.39 a
Control (100% of IR)	2.40 b	2.39 a	26.15 c	35.12 b	1.07 e	1.06c

PRD: partial root-zone drying technique IR: irrigation requirements
Means having the same letter (s) in each column are insignificantly different

Table 5. Terminal buds and young leaves phyto-hormones contents and endogenous enzymes activities of "Le Conte" pear trees as influenced by irrigation technique and anti-transpiration materials or mulching during 2019 season

Treatments	IAA	GA_3	ABA	Polyphenol oxidase (PPO)	Peroxidase (PRO)
	(mg/100g f.wt)			(unit mg-1 protein)	
PRD at 50% of IR with kaolin	340.0 d	118.5 cd	540.0 b	11.83 b	3.31 b
PRD at 75% of IR with kaolin	462.0 a	137.3 a	313.0 h	9.96 de	2.42 c
PRD at 50% of IR with green miracle	304.7 e	115.4 d	541.0 b	11.51 b	3.27 b
PRD at 75% of IR with green miracle	422.0 b	135.5 a	422.0 e	9.63 e	1.89 d
PRD at 50% of IR with mulching	347.0 cd	124.8 bc	502.0 d	10.53 c	2.50 c
PRD at 75% of IR with mulching	350.7 c	132.5 ab	389.0 f	10.13 cd	2.43 c
PRD at 50% of IR	289.0 f	89.80 e	550.0 a	13.81 a	3.73 a
PRD at 75% of IR	310.0 e	110.2 d	531.0 c	11.45 b	2.55 c
Control (100% of IR)	422.0 b	129.2 ab	376.7 g	10.05 d	2.38 c

PRD: partial root-zone drying technique IR: irrigation requirements
Means having the same letter (s) in each column are insignificantly different

of IAA was occurred with kaolin spraying with irrigation at a rate of 75% using the PRD technique, followed by irrigation at a rate of 100% by the normal method. As for the content of GA3, irrigation with PRD at 75% of IR with anti-transpiration or mulching achieved the highest content and significantly equal to that achieved when irrigating with optimum rate (100%).

In the same Table (5) the highest values of ABA were recorded with the lowest irrigation rate without additives. While under PRD irrigation rates, the use of antiperspirant or mulching treatment led to a significant decrease in ABA compared to the non-additional treatment. On the contrary, the irrigation rate at optimum rate (100%) recorded the lowest value, followed by irrigation at PRD at 75% of IR combined with mulching or kaolin treatments.

A significant highest polyphenol oxidase (PPO) was detected by PRD at 50% of IR without any additive, compared to the lowest values occurs by PRD at 75% of IR with green miracle or with kaolin and followed by applying optimum rate (100%). With irrigation by PRD at 50% and 75% of IR, applying kaolin and green miracle or usage the mulch decreased the value of PPO as compared to these irrigation treatments without additive treatments (Table, 6). Almost the same results were achieved for peroxidase (PRO), where the highest value was occurred with the highest rate of drought with irrigation by PRD at 50% of IR without any additions. On the contrary, it achieved the least activity with PRD at 75% of IR with green miracle. Also, the values achieved with PRD at 75% of IR without additive or with kaolin or mulching were significantly equal to those achieved with optimum rate (100%). The use of additional materials had a significant effect on reducing the activity of PRO (Table, 5).

3.4.Effect of irrigation technique and anti-transpiration materials or mulching on fruit set percentage and yield (kg/ tree):

The highest percentage of fruit set was achieved significantly by using PRD at 75% of IR and accompanied with soil mulching or accompanied by spraying anti-transpiration materials (Kaolin and Green Miracle) superior to normal irrigation (100% of IR) during the year of 2018. As well as irrigation at 100% of IR (control treatment) in 2019 season, the lowest significantly percentage of fruit set was achieved by adding 50% of the irrigation requirement using the PRD method alone or combined with kaolin or mulching (Table, 6) .

Also, irrigation using a rate of 75% of IR by the PRD technique combined with green miracle or mulching achieved a statistically higher amount of tree yield in 2018, compared to irrigation with 100% of IR by the normal way. In the 2019 season, the highest yield was achieved with the use of an irrigation rate at 75% of IR by the PRD technique combined with either of the two anti-transpiration materials or combined with soil mulching or with the use of an irrigation rate 50% of IR by the PRD technique accompanied by soil mulching. The same results were achieved with trees irrigated with 100% of IR under the normal method. In addition, irrigation by 75% of IR using the PRD technique was statistically equal in the same amount of the yeild in both years with irrigation at a rate of 100 of IR in the normal way (Table, 6).

Table 6. Final fruit set (%) and yield (kg/tree) of "Le Conte" pear trees as influenced by irrigation technique and anti-transpiration materials or mulching during 2018 and 2019 seasons

Treatments	Final fruit set (%)		Yield ((kg/tree)	
	2018	2019	2018	2019
PRD at 50% of IR with kaolin	5.80 ef	6.50 c	65.80 c	65.33 c
PRD at 75% of IR with kaolin	6.90 ab	8.03 a	76.50 b	73.50 ab
PRD at 50% of IR with green miracle	6.10 de	6.90 bc	75.60 b	70.50 bc
PRD at 75% of IR with green miracle	6.80 ab	7.50 ab	83.53 a	74.30 ab
PRD at 50% of IR with mulching	5.70 ef	7.20 b	73.80 b	73.13 ab
PRD at 75% of IR with mulching	7.10 a	7.90 a	83.33 a	77.50 a
PRD at 50% of IR	5.60 f	6.50 c	65.60 c	55.20 d
PRD at 75% of IR	6.33 cd	7.10 bc	75.70 b	69.47 bc
Normal irrigation (100% of IR)	6.69 bc	8.10 a	76.23 b	74.23 ab

PRD: partial root-zone drying technique IR: irrigation requirements
Means having the same letter (s) in each column are insignificantly different

3.5.Effect of irrigation technique and anti-transpiration materials or mulching on fruit weight and fruit hardness:

The results in Table (7) significantly show the production of irrigated pear trees at a rate of 75% of IR with the PRD method, which was accompanied by spraying with anti-transpiration materials or covering the soil with polyethylene for the highest fruits weight compared to the rest of treatments and irrigation at a rate of 100% by the normal method. This was true in both seasons, except for the green miracle in the second year. Also, the average fruit weight of trees irrigated with the normal technique by 100% of IR was statistically equal to that irrigated with lower rates but with PRD method, where it was equal with irrigation by 75% in the first season and equal with both lower rates 75% or 50% of IR in the second season.

In the same Table (7), the highest significant fruit hardness in the first season was recorded with irrigation with the lowest irrigation rate of 50% of IR with the PRD method, either alone or accompanied by kaolin spray. Whereas the lowest fruit hardness was achieved with PRD at 75% of IR was associated with green miracle, or with a rate of PRD at 50% of IR associated with covering the soil. The results were significantly similar in the second season.

Table 7. Fruit weight (g) and fruit hardness (Newton) of "Le Conte" pear trees as influenced by irrigation technique and anti-transpiration materials or mulching during 2018 and 2019 seasons

Treatments	Fruit weight (g)		Fruit firmness (Newton)	
	2018	2019	2018	2019
PRD at 50% of IR with kaolin	183.4 b	180.6 b	97.28 ab	85.40 a-c
PRD at 75% of IR with kaolin	189.6 ab	190.8 a	91.50 bc	81.26 bc
PRD at 50% of IR with green miracle	183.5 b	182.5 b	91.94 bc	87.05 ab
PRD at 75% of IR with green miracle	192.3 a	193.2 b	85.85 c	80.95 c
PRD at 50% of IR with mulching	188.5 ab	182.2 b	86.42 c	86.60 a-c
PRD at 75% of IR with mulching	193.4 a	188.7 a	86.74 c	87.05 ab
PRD at 50% of IR	168.2 d	162.6 c	101.86 a	89.40 a
PRD at 75% of IR	172.5 cd	181.0 b	92.52 bc	84.96 a-c
Normal irrigation (100% of IR)	175.3 c	180.2 b	93.10 bc	85.54 a-c

PRD: partial root-zone drying technique IR: irrigation requirements
Means having the same letter (s) in each column are insignificantly different

3.6.Effect of irrigation technique and anti-transpiration materials or mulching on the sunlight intensity penetrating trees and its relationship to red-cheek and burnt fruit:

In general, the maximum percentage of light that penetrated the trees was obtained with the lowest irrigation rate (PRD at 50% IR) without any additives, which produced the highest percentage of red-cheeked fruits, but also it achieved with the highest percentage of sunburn damaged fruits. Conversely, the trees irrigated with 100 % of IR had the lowest light intensity, resulting in the lowest percentage of red-cheeked fruits as well as the lowest percentage of burnt fruits. With covering soil combined with trees irrigated by 50 or 75 % of IR using the PRD technique or with PRD at 75 % of IR with green miracle, the same results of light intensity entering trees were attained as with trees irrigated by 100 % of IR. Furthermore, PRD's irrigation treatment of 75 % IR with mulching resulted in an acceptable balance between red-cheeked and burnt fruit percentages (Table, 8).

4. DISCUSSION

Based on the above mentioned results, the good effect of using PRD technology alone or in combination with spraying with an anti-transpiration or mulching treatments on leaf nutrients, chlorophyll, and carbohydrates contents (Tables 3, 4) which showed an achievement of

Table 8. Sun light intensity (lux), red-cheek fruit (%) and burnt fruit (%) of "Le Conte" pear trees as influenced by irrigation technique and anti-transpiration materials or mulching during 2019 season

Treatments	Sun light intensity (lux)	Red-cheek fruit (%)	Burnt fruit (%)
PRD at 50% of IR with kaolin	10610 c	13.40 bc	14.57 c
PRD at 75% of IR with kaolin	35810 b	11.50 d	11.70 e
PRD at 50% of IR with green miracle	40290 b	13.63 bc	14.80 bc
PRD at 75% of IR with green miracle	12350 c	12.00 d	13.43 c-e
PRD at 50% of IR with mulching	10690 c	11.43 d	16.77 b
PRD at 75% of IR with mulching	10460 c	12.50 cd	13.80 cd
PRD at 50% of IR	66130 a	16.23 a	19.00 a
PRD at 75% of IR	37740 b	14.13 b	14.17 c
Control (100% of IR)	8851 c	7.46 e	12.05 de

PRD: partial root-zone drying technique IR: irrigation requirements
Means having the same letter (s) in each column are insignificantly different

irrigation rate at 75% IR using the PRD technique, results similar to or close to those achieved with full irrigation rate (100% IR) or exceeded with the full irrigation rate when combined with anti-transpiration treatments or using mulch can be explained as follows. Plant nutrient uptake is greatest under PRD treatment compared to full irrigation in many plants (Sun et al., 2013; Wang et al., 2013). This is due to the formation of new roots during PRD, which leads to higher nutrient uptake from the soil due to the additional availability of soil water (Kang and Zhang 2004), as well as the fact that the irrigated side of the PRD technique used water more effectively than the whole irrigated plant (Kang et al., 2000b). As well as Dodd et al. (2015) explaining the increased uptake of nitrogen and phosphorous from various PRD-treated crops, science re-wetting previously dry soil increases nitrogen mineralization. Whereas, changes in physical processes (soil aggregation disturbance and subsequent release of reactive P-form), biological processes (activation of soil microbial biomass and actions in the mineralization of soil organic compounds), and the coupling of both processes. Additionally, Ramírez et al. (2014) observed that with PRD treatment, there is an enhancement in leaves chlorophyll content also leaves chlorophyll concentration is an indicator of yield under water-deficient conditions. Also, the higher activity of antioxidants, as shown in Table (5), has a role in increasing nutrient contents, which was consistent with the results of Jensen et al. (2010) and Jovanovic et al. (2010). They showed that strong antioxidant activity in PRD-treated tomato and potato plants improved the nutritional content of the plants.

Anti-transpiration may have a good influence on the plant's ability to acquire and transfer nutrients (Havlin et al., 2005). The positive significant effect of anti-transpiration spray treatment on total chlorophyll content, N, P, K, and Fe, as indicated by Glenn et al. (2002), may be attributed to its cooling action since it reduces leaf temperature. In other words, it plays a crucial function in preventing heat stress injury, which is reflected in nutrient absorption. Furthermore, the antiperspirant was responsible for a considerable increase in total chlorophyll and a decrease in total phenols (Ahmed and Ahmed, 2014). Also, since the protective mechanism for higher brightness consists of regulating the loss of chlorophyll by chloroplasts, leaves untreated with anti-transpiration may show lower light reflectance, indicating increased degradation of photosynthetic pigments, suggesting increased degradation of photosynthetic pigments (Anderson, 1986). Furthermore, aside from its weed-control and water-saving benefits, plastic mulch improves soil properties such as temperature, moisture content, bulk density, general stability, and nutrient availability, all of which benefit plant development and yield (Lalitha et al., 2010). Mulching can also help minimize evaporation and hence boost plant water availability by reducing evaporation (Langdale et al., 1992). Pinamonti (1998) discovered that applying non-woven polypropylene mulch improves K and Mg in apples when compared to commercial control. Fawzia (2008) also found that black plastic mulch enhanced the amounts of P, N, and chlorophyll in the leaves of Le Conte pear.

About phenols, poly phenol oxidase (PPO) and peroxidase (PRO), the highest activity was produced by PRD at 50% of IR without any additive, compared to the lowest values occurs by PRD at 75% of IR with green miracle (Tables 4, 5). This is because plants have evolved different adaptive mechanisms to decrease oxidative damage from water deficiency, through the biosynthesis of a cascade of antioxidants. The antioxidant system, for example, acts as a defense mechanism against the absorption of reactive oxygen species (Sadak et al., 2020). Peroxidase (PRO) regulates the growth rate of plant by biochemically altering cell wall characteristics, resulting in slower cell wall expansion (Fry, 1995), play a role in lignification and improved lignification rates and thus inactivating auxin (Sofo et al., 2005). Furthermore, polyphenol oxidase (PPO) participates in the metabolism of phenols which are also important antioxidants (Rice-Evans et al., 1997). The activity of the antioxidant enzymes increases with the intensity of water stress (Sofo et al., 2005). PRO and PPO were up regulated by the PRD compared with control values on olives whereas the high activities of PRO observed in PRD at 50% may reflect the greater inhibitory effect on vegetative growth. The Up regulation of the detoxifying systems in the PRD may have provided protective mechanisms against irreversible damage of photosynthesis process, enabling the photosynthetic apparatus to function, and averting the onset of severe water stress (Aganchich et al., 2009) .

Overall, the results of the highest yield and the best fruit characteristics, such as weight, hardness, red cheek fruit as well to achieve a reasonable percentage of burnt fruit (Tables 6, 7) were associated with higher nutrients, chlorophyll, carbohydrate content which obtained with PRD at 75% of IR plus anti-transpiration or mulching which are superior or similar to or close to that achieved with full irrigation rate (100%). Which was also associated with a higher content of phyto-hormones (IAA, GA3) obtained with PRD at 75% of IR plus anti-transpiration or mulching achieved the highest content and significantly equal with that achieved when irrigating with optimum rate or achieved with the lowest PPO and PRO obtained with same treatment. Furthermore, PRD at 75% of IR treated with anti-transpiration or mulching had good phyto-hormones content, which is not only essential for plant growth and development, but also plays a key role in controlling plant responses to various abiotic stress situations (Gururani et al., 2015). ABA-independent control of ion channels by osmotic stress, calcium and protein concentrations, and phosphatase all have a function in ABA signaling for sentinel cell movement, in addition to the effect of ABA hormone in regulating stomata water loss (Luan, 2002) .

In addition, under the drip irrigation system, the rationalization of water by reducing the irrigation quantities by 25% of the optimal rate using the PRD technique, especially when mixed with the use of anti-transpiration or mulching, gave similar or superior results to the use of the full level (100% of IR) of water in irrigation "Le Conte" pear trees for all the traits under study, this is due to the many advantages of the PRD technique regarding deficit irrigation. Its key advantage is that the irrigated portion supplies water to the plants, ensuring that the water potential is maintained at a level that does not cause stress to the plants. ABA production is also increased in the dry part, which lowers stomata conduction (Iqbal et al. 2019a). Several studies suggest that while the PRD approach reduces stomatal conductance, the photosynthetic rate remains the same in well irrigated plants (Costa et al., 2007; Ahmadi et al., 2010). This positive effect is attributed to PRD's ability to improve plant root extension (Kang et al., 2000b), root growth (Dry et al., 2000), and root biomass (Kang et al., 2000a), ABA concentrations enhanced hydraulic conductivity, and enhanced plant nutrients absorbed (Wang et al., 2009). Due to improved hydraulic conductivity following the low water stress condition of the soil, dry soils in the PRD display greater water uptake (Kang and Zhang, 2004). Therefore, the percentage of the fruit set and weight and yield were statistically equal, when irrigation at a rate of 75% of IR using the PRD technique with irrigation at a rate of 100 of IR in the normal way. And it excels when combined with the use of mulch or spraying with anti-transpiration. Wahbi et al. (2005) cleared through their evaluation of the main olive tree species; they showed that by using PRD, which may be able to maintain end product output and quality despite a reduction in irrigation system water. In addition, Costa et al. (2007) and Ahmad et al. (2020) showed that water productivity (crop yield per unit of irrigation water applied) for different crop species increased mainly during the application of the PRD. Also, Sadras (2009) explained that PRD increases water productivity by 82 % when compared to fully watered plants.

Moreover, the use of antiperspirants reduced the negative impact on fruit set that were placed under the deficient irrigation regime. The positive effect of anti-transpiration application may be due to the improvement of the plants' water condition and photosynthetic activities (Glenn et al., 2003). While the particle films containing kaolin showed that the reflective nature of the plant surface can improved plant productivity, as the yield increased as a result of increasing the number of fruits, and to successfully protect the fruits from fly infestation and reduce fruit and weight disturbances (Glenn and Buterka, 2005). The increase in fruit yield as a result of the use of anti-transpiration materials such as kaolin may be due to its protective effect from high temperature and reflection of solar radiation (Mahmoudian et al., 2021), especially ultraviolet wavelengths, which reduced the heat stress of the fruit, and enhanced the fruit water content by reducing transpiration from the surface of the fruit (Glenn and Buterka, 2005). Also, kaolin foliar applications increased yield and enhanced fruit quality of Japanese persimmon tree (Abo Ogiela, 2020). The use of anti-transpiration agents also had a preventative impact, lowering the percentage of burnt fruit (Table, 8). Furthermore, according to EL-Gioushy et al. (2017), spraying trees with green miracle reduced the quantity of scorched fruits per tree. While anti-transpiration as kaolin has a protective effect from high temperatures and solar radiation reflection (Mahmoudian et al., 2021), especially ultraviolet wavelengths, which reduced the heat stress of the fruit and increased the fruit water content by reducing transpiration from the fruit's surface (Glenn and Buterka, 2005). However, mulching had an effect on soil moisture and hence enhanced the PRD water system's efficiency (Kader et al., 2019; Iqbal et al., 2020). Mulch treatment also influenced fruit set (Patra et al., 2003), encouraged vegetative development, and increased fruit production (Singh et al., 2007).

For trees irrigated with the lowest irrigation rate (PRD at 50% of IR) without any additives, the highest light penetration was achieved for trees, while the lowest was achieved with that irrigated with the optimum rate (100 % of IR). The highest percentage of the red-cheeked or sun- burned fruits were correlated with the highest light penetration; on the contrary, the lowest light rate achieved the lowest red-cheeked or sun- burned fruits percentage (Table, 8). This can be attributed to the negative effect of water shortage on growth. The vegetative growth of the plant, in general, and the resulting leaf extension, in particular, are severely hampered by the water stress. Also, water stress negatively affects cell division and enlargement (Hussain et al., 2008 and Fahad et al., 2017). Also, the correlation of take of fruits to a red cheek with the amount of light achieved, this explains it the red color in the fruit is expressed by the presence of flavonoid pigments called anthocyanins. Anthocyanin synthesis in fruit is a function of endogenous and exogenous factors (Thomson et al., 2018). External factors, such as temperature, light, tree nutrition, crop and cultural management practices, can modify the amount of anthocyanins accumulated, as the pear develops, blush appears on surfaces exposed to direct sunlight (Dussi Dehais, 1993). Furthermore, the lack of irrigation results in high canopy light transmission which may lead to burnt fruit in warm production areas with high solar radiation (Tarara et al., 2008). PRD also has a considerable impact on secondary metabolites of specific relevance, such as phytochemicals with quality or health-related qualities, as well as antioxidants in fruits and cereals. Antolin et al. (2006) found that increases in ABA increased anthocyanin content under PRD, and that increased mRNA induced the accumulation of genes involved in the biosynthetic anthocyanin pathway (Jeong et al., 2004). The better peel colour of apple fruit under PRD was due to changes in canopy structure, according to PRD technology (Francaviglia et al., 2013). Furthermore, Romero et al. (2016) found that increased ABA and salicylic acid content, as well as decreased vegetative growth and increased canopy light penetration in PRD vines, may have an increased effect on the production of phenolic compounds that serve as antioxidants, anthocyanin stabilizers, wine color, and other functions. While the use of anti-transpiration agents such as kaolin, which creates a white coating that reflects some sunlight, protecting against high temperatures resulting in reduced heat stress on the fruit and enhanced water content in the fruit by reducing transpiration from the surface of the fruit (Glenn and Buterka, 2005). Also, EL-Gioushy et al. (2017) indicated that sprayed trees with green miracle decreased the number of sunburned fruits per tree. Therefore, the achievement of irrigation with PRD technique at a rate of 75% of IR with covering the surface of the soil with plastic or with spraying by anti-transpiration materials achieved a reasonable balance between the red-cheeked fruits and burnt fruits percentage. This is due to what this technique achieves in terms of saving water and what the use of mulch achieves in saving water from the soil and what anti-transpiration achieves by reducing the harmful effect of increased exposure to sunlight.

5. CONCLUSION

The results demonstrated that, under a drip irrigation system, water can be conserved by reducing irrigation amounts by 25% of the optimal rate by using PRD technique especially when combined with the use of mulching or the use of anti-transpiration materials. Whereas it gave superior or similar results to the results achieved for studied traits when using the full irrigation rates in the traditional way without any additional treatments .

6. REFERENCES

Abo Ogiela HMA (2020). Effect of kaolin foliar on fruit sunburn, yield and fruit quality of persimmon trees. Menoufia J. of Plant Production, 5(4), 181-194. https://dx.doi.org/10.21608/mjppf.2020.171212

Aganchich B, Wahbi S, Loreto F and Centritto M (2009). Partial root zone drying: Regulation of photosynthetic limitations and antioxidant enzymatic activities in young olive (Olea europaea) saplings. Tree Physiology, 29(5):685-696. https://doi.org/10.1093/treephys/tpp012

Ahmad S, Raza MAS, Saleem MF, Zaheer MS, Iqbal R, Haider I, Aslam MU, Ali M and Khan IH (2020). Significance of partial root zone drying and mulches for water saving and weed suppression in wheat. J. Anim. Plant. Sci. 30:154–162. http://www.thejaps.org.pk/docs/Accepted/2020/30-01/09.pdf

Ahmadi SH, Andersen MN, Plauborg F, Poulsen RT, Jensen CR, Sepaskhah AR and Hansen S (2010). Effects of irrigation strategies and soils on field grown potatoes: Gas exchange and xylem [ABA]. Agric. Water Manag., 97:1486–1494. https://doi.org/10.1016/j.agwat.2010.05.002

Ahmed YMA and Ahmed M (2014). Impact of spraying some antitranspirants on fruiting of Williams bananas grown under Aswan region conditions. Stem Cell, 5(4), 34-39.

Anderson JM (1986). Photoregulation of the composition, function and structure of thylakoid membranes. Annu. Rev. Plant Phys., 37:93-136. https://doi.org/10.1146/annurev.pp.37.060186.000521

Antolin MC, Ayari M and Sánchez-Díaz MA (2006). Effects of partial rootzone drying on yield, ripening and berry ABA in potted Tempranillo grapevines with split roots. Australian J. of Grape and Wine Research, 12(1), 13-20. https://doi.org/10.1111/j.1755-0238.2006.tb00039.x

AOAC (Association of Official Agriculture Chemists) (1990). Official methods of analysis. 15th Ed., Washington D.C., USA.

Bakht J, Shafi M, Yousaf M and Khan MA (2010). Effect of irrigation on physiology and yield of sunflower hybrids. Pak J. Bot., 42:1317–1326. http://www.pakbs.org/pjbot/PDFs/42(2)/PJB42(2)1315.pdf

Chapman HD and Pratt PF (1961). Method of analysis for soils, plants and waters, University of California (Riverside) Division of Agriculture Sciences. Agr. Publ. Office, Univ. Hall Univ. Calif., Berkeley, USA.

Costa JM, Ortuño MF and Chaves MM (2007). Deficit irrigation as a strategy to save water: physiology and potential application to horticulture. J. of integrative plant biology, 49(10), 1421-1434. https://doi.org/10.1111/j.1672-9072.2007.00556.x

Cottenie A (1980). Soils and plant testing as a basis of fertilizer recommendation. FAO Soil Bull., 3812. https://www.fao.org/publications/card/ar/c/0cb68c2a-5a84-5882-9085-15f34d6b6aa0/

De la Hera ML, Romero P, Gomez-Plaza E and Martinez A (2007). Is partial root-zone drying an effective irrigation technique to improve water use efficiency and fruit quality in field-grown wine grapes under semiarid conditions? Agric. Water Manag., 87:261–274. https://doi.org/10.1016/j.agwat.2006.08.001

Dhindsa RS, Plumb Dhindsa P and Thorpe TA (1981). Leaf senescence correlated with increased levels of membrane permeability and lipid peroxidation, and decreased levels of superoxide dismutase and catalase. J. of Experimental Botany, 32: 93–101. https://doi.org/10.1093/jxb/32.1.93

Dodd IC, Puértolas J, Huber K, Pérez-Pérez JG, Wright HR and Blackwell MS (2015). The importance of soil drying and re-wetting in crop phytohormonal and nutritional responses to deficit irrigation. J. of experimental botany, 66(8), 2239-2252. https://doi.org/10.1093/jxb/eru532

Dry PR, Loveys BR and Düring H (2000). Partial drying of the rootzone of grape. II. Changes in the pattern of root development. Vitis, 39(1), 9-12. https://doi.org/10.5073/vitis.2000.39.9-12

Dussi Dehais MC (1993). Fruit color development in red pears. M. Sc. Thesis, Oregon State Univ. https://www.researchgate.net/publication/281625058_AN_ABSTRACT_OF_THE_THESIS_OF_Title_Fruit_Color_Development_In_Red_Pears

EL-Gioushy SF, Baiea MHM, Abdel Gawad-Nehad MA and Amin OA (2017). Influence of $CaCO_3$ and green miracle foliar application on preventing sunburn injury and quality improvement of Keitt mango fruits. East J. Agric. Res., 6(4):1098-1110. https://www.curresweb.com/mejar/mejar/2017/1098-1110.pdf

Fahad S, Bajwa AA, Nazir U, Anjum SA, Farooq A, Zohaib, Sadia A, Nasim S, Adkins WS, Saud S, Ihsan MZ, Alharby H, Wu C, Wang D and Huang J (2017). Crop Production under Drought and Heat Stress: Plant Responses and Management Options. Frontiers in plant science, 8, 1147. https://doi.org/10.3389/fpls.2017.01147

Fales HN, Jaouni TM and Babashak JF (1973). Simple device for preparing etheral diazomethane without resorting to codistillation. Anal Chem., 45:2302–2303. https://pubs.acs.org/doi/abs/10.1021/ac60335a020

Fawzia ME (2008). Effect of the use of coloured plastic mulching on growth, yield components and fruit quality of Le-Conte pear trees. Minufia J. Agric Res. 33(5): 1157-1177.

Francaviglia D, Farina V, Avellone G and Bianco RL (2013). Fruit yield and quality responses of apple Cvars Gala and Fuji to partial rootzone drying under Mediterranean conditions. The J. of Agric. Sci., 151(4), 556-569. https://doi.org/10.1017/S0021859612000718

Fry SC (1995). Polysaccharide-modifying enzymes in the plant cell wall. Annual review of plant biology, 46(1), 497-520. https://doi.org/10.1146/annurev.pp.46.060195.002433

Glenn DM, and Puterka GJ (2005). Particle Films: A new technology for agriculture. Hort. Reviews, 31. Edited by Jules Janick. John Wiley & Sons, Inc. http://dx.doi.org/10.1002/9780470650882.ch1

Glenn DM, Prado E, Erez A, Ferson GM and Puterka GJ (2002). A reflective processed kaolin particle film affects fruit temperature, radiation reflection and solar injury in apple. J. Amer. Soc. Hort. Sci., 126(2):188-193. https://doi.org/10.21273/JASHS.127.2.188

Glenn DM, Erez A, Puterka GJ and Gundrum P (2003). Particle films affect carbon assimilation and yield in 'Empire' apple. J. Amer. Soc. Sci., 128:356-362. https://doi.org/10.21273/JASHS.128.3.0356

Gururani MA, Mohanta TK and Bae H (2015). Current understanding of the interplay between phytohormones and photosynthesis under environmental stress. International J of molecular sci., 16(8), 19055-19085. https://dx.doi.org/10.3390%2Fijms160819055

Hussain M, Malik MA, Farooq M, Ashraf MY and Cheema MA (2008). Improving Drought tolerance by exogenous application of glycinebetaine and salicylic acid in sunflower. J. Agron. Crop Sci. 194 193–199. https://doi.org/10.1111/j.1439-037X.2008.00305.x

Havlin JL, Beaton JD, Tisdale SL and Nelson WL (2005). Soil fertility and fertilizers: an introduction to nutrient management. 7th Ed. Prentice Hall, Upper Saddle River, Nj.

Ibrahim EA and Selim EM (2010). Effect of irrigation intervals and antitranspirant (kaolin) on summer squash (*Cucumber pepo* L.) growth, yield quality and economics. J. of Soil Sci. and Agri. Eng., Mansoura Univ., 1: 883-894. https://dx.doi.org/10.21608/jssae.2010.75212

Iqbal R, Andersen MN, Raza MAS, Rashid MA and Ahmad S (2019a). Physiological manipulation and yield response of wheat grown with split root system under deficit irrigation. Pak J. Agric. Res., 32:514–526. http://dx.doi.org/10.17582/journal.pjar/2019/32.3.514.526

Iqbal R, Raza MAS, Valipour M, Saleem MF, Zaheer MS, Ahmad S and Nazar MA (2020). Potential agricultural and environmental benefits of mulches-a review. Bull Natl. Res. Cent., 44:1–16. https://doi.org/10.1186/s42269-020-00290-3

Jackson ML (1973). Soil Chemical Analysis, Prentice Hall of India. Ltd., New Delhi.

Jensen CR, Battilani A, Plauborg F, Psarras G, Chartzoulakis K, Janowiak F and Andersen MN (2010). Deficit irrigation based on drought tolerance and root signalling in potatoes and tomatoes. Agric. Water Manag., 98(3), 403-413. https://doi.org/10.1016/j.agwat.2010.10.018

Jeong ST, Goto-Yamamoto N, Kobayashi S and Esaka MJPS (2004). Effects of plant hormones and shading on the accumulation of anthocyanins and the expression of anthocyanin biosynthetic genes in grape berry skins. Plant Sci., 167(2), 247-252.

https://doi.org/10.1016/j.plantsci.2004.03.021

Jovanovic Z, Stikic R, Vucelic-Radovic B, Paukovic M, Brocic Z, Matovic G and Mojevic M (2010). Partial root-zone drying increases WUE, N and antioxidant content in field potatoes. European J. of Agronomy, 33(2), 124-131. https://doi.org/10.1016/j.eja.2010.04.003

Kader MA, Singha A, Begum MA, Jewel A, Khan FH and Khan NI (2019). Mulching as water-saving technique in dryland agriculture. Bulletin of the National Research Centre, 43(1), 1-6. http://dx.doi.org/10.1186/s42269-019-0186-7

Kang SZ and Zhang JH (2014). Controlled alternate partial root-zone irrigation: its physiological consequences and impact on water use efficiency. J. Exp. Bot., 55:2437–2446. https://doi.org/10.1093/jxb/erh249

Kang SZ, Shi P, Pan YH, Liang ZS, Hu XT and Zhang J (2000b). Soil water distribution, uniformity and water-use efficiency under alternate furrow irrigation in arid areas. Irrigation Sci., 19(4), 181-190. https://doi.org/10.1007/s002710000019

Kang S, Liang Z, Pan Y, Shi P and Zhang J (2000a). Alternate furrow irrigation for maize production in an arid area. Agric. Water Manag., 45(3), 267-274. https://doi.org/10.1016/S0378-3774(00)00072-X

Khalil ML (2006). Biological activity of bee propolis in health and disease. Asian Pac. J. Cancer Prev. 7, 22–31. http://journal.waocp.org/article_24421_e27f12cfb64e899d4a0ee2f315f985bf.pdf

Khan AJ, Azam F and Ali A (2010). Relationship of morphological traits and grain yield in recombinant inbreed wheat lines grown under drought conditions. Pak J. Bot., 42:259–267. http://pakbs.org/pjbot/PDFs/42(1)/PJB42(1)259.pdf

Lalitha M, Thilagam VK, Balakrishnan N and Mansour M (2010). Effect of plastic mulch on soil properties and crop growth-A review. Agric. Reviews, 31(2), 145-149. https://arccjournals.com/journal/agricultural-reviews/ARCC1349

Langdale GW, West LT, Bruce RR, Miller WP and Thomas AW (1992). Restoration of eroded soil with conservation tillage. Soil technology, 5(1), 81-90. https://doi.org/10.1016/0933-3630(92)90009-P

Leib BG, Caspari HW, Redulla CA, Andrews PK and Jabro J (2006). Partial root-zone drying and deficit irrigation of ‘Fuji’ apples in a semi-arid climate. Irrig. Sci., 24: 85–99. https://doi.org/10.1007/s00271-005-0013-9

Luan S (2002). Signalling drought in guard cells. Plant, Cell & Environment, 25: 229–237 https://doi.org/10.1046/j.1365-3040.2002.00758.x

Macheix JJ and Quessada MP (1984). Caractérisation d’une peroxydase impliquée spécifiquement dans la lignification, en relation avec l’incompatibilité au greffage chez l’Abricotier. Physiologie Végétale, 22:533-540.

Mahmoudian M, Rahemi M, Karimi S, Yazdani N, Tajdini Z, Sarikahni S and Vahdati K (2021). Role of kaolin on drought tolerance and nut quality of Persian walnut. J. of the Saudi Soci. of Agric. Sci., 20: 409-4016. http://dx.doi.org/10.1016/j.jssas.2021.05.002

Moran R (1982). Formulae for determination of chlorophyllous pigments extracted with N, N-dimethylformamide. Plant Physiol., 69:1376–1381. https://dx.doi.org/10.1104%2Fpp.69.6.1376

Obaje SO, Omada JI and Dambatta UA (2013). Clays and their industrial applications: Synoptic review. Inter. J. Sci. & Tech., 3 (5): 264 270. http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.415.8924

Patra RK, Das BC and Hasan MA (2003). Flowering behavior and fruit yield of guava. Cv. Sardar as influenced by different soil cover. Research on crops, 4(3):383-387.

Pinamonti F (1998). Compost mulch effects on soil fertility, nutritional status and performance of grapevine. Nutrient Cycling in Agroecosystems, 51(3), 239-248. https://doi.org/10.1023/A:1009701323580

Ramírez DA, Yactayo W, Gutiérrez R, Mares V, Mendiburu Fde, Posadas A and Quiroz R (2014). Chlorophyll concentration in leaves is an indicator of potato tuber yield in water-shortage conditions. Sci. Hortic. 168, 202–209. https://doi.org/10.1016/j.scienta.2014.01.036

Rashid MA, Zhang X, Andersen MN and Olesen JE (2019). Can mulching of maize straw complement deficit irrigation to improve water use efficiency and productivity of winter wheat in North China Plain? Agric. Water Manag., 213:1–11. http://dx.doi.org/10.1016/j.agwat.2018.10.008

Rice-Evans C, Miller N and Paganga G (1997). Antioxidant properties of phenolic compounds. Trends in plant sci., 2(4), 152-159. https://doi.org/10.1016/S1360-1385(97)01018-2

Romero P, García JG, Fernández-Fernández JI, Muñoz RG, del Amor Saavedra F and Martínez-Cutillas A (2016). Improving berry and wine quality attributes and vineyard economic efficiency by long-term deficit irrigation practices under semiarid conditions. Scientia Horticulturae, 203, 69-85. https://doi.org/10.1016/j.scienta.2016.03.013

Quinet M and Wesel JP (2019). Botany and taxonomy of pear. The Pear Genome, pp.1-33. https://doi.org/10.1007/978-3-030-11048-2_1

Sadak MS, Abdalla AM and Abd Elhamid EM (2020). Role of melatonin in improving growth, yield quantity and quality of *Moringa oleifera* L. plant under drought stress. Bull. Natl. Res. Cent., 44:18. https://doi.org/10.1186/s42269-020-0275-7

Sadras VO (2009). Does partial root-zone drying improve irrigation water productivity in the field? A meta-analysis. Irrig. Sci., 27(3), 183-190. http://dx.doi.org/10.1007/s00271-008-0141-0

Saied IA, Mokhtar H and Salim AA (1993). Comparative studies on weed control methods in pear trees. J. of Agri. Sci., Mansoura Univ.. 18(1):257-265.

Singh BK,Tiwari KN, Chourasia SK and Mandal S (2007). Crop water requirement of guava (*Psidium guajava* L.) cv. KG/Kaji under drip irrigation and plastic mulch. Acta Hort., 735: 399-405. https://doi.org/10.17660/ActaHortic.2007.735.56

Singleton VL and Rossi JA (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Am. J. Eno. Vitic., 16: 144-158. https://www.ajevonline.org/content/16/3/144

Smith N (1991). "CROPWAT" model for Eto calculation using Penman Monteith Method. FAO, Rome , Italy. https://www.fao.org/3/x0490e/x0490e08.htm

Snedecor W and Cochran WG (1989). Statistical Methods, 8th ed. Iowa State Univ. Press Ames. Iowa. U.S.A. 296p.

Sofo A, Dichio B, Xiloyannis C and Masia A (2005). Antioxidant defences in olive trees during drought stress: changes in activity of some antioxidant enzymes. Funct. Plant Biol., 32:45-53. https://doi.org/10.1071/fp04003

Sun Y, Yan F and Liu F (2013). Drying/rewetting cycles of the soil under alternate partial root-zone drying irrigation reduce carbon and nitrogen retention in the soil-plant systems of potato. Agric. Water Manage., 128, 85–91.

https://doi.org/10.1016/j.agwat.2013.06.015

Tarara JM, Lee J, Spayd SE and Scagel CF (2008). Berry temperature and solar radiation alter acylation, proportion, and concentration of anthocyanin in Merlot grapes. Am. J. Eno. Vitic., 59(3), 235-247. https://www.ajevonline.org/content/59/3/235.abstract?cited-by=yes&legid=ajev;59/3/235

Tawfik RS and El-Mouhamady ABA (2019). Molecular genetic studies on abiotic stress resistance in sorghum entries through using half diallel analysis and inter simple sequence repeat (ISSR) markers. Bull. Natl. Res. Cent., 43:117. https://doi.org/10.1186/s42269-019-0155-1

Thomson GE,Turpin S and Goodwin I (2018). A review of preharvest anthocyanin development in full red and blush cultivars of European pear. New Zealand J. of Crop and Horti. Sci., 46(2), 81-100. https://doi.org/10.1080/01140671.2017.1351378

Wahbi S, Wakrim R, Aganchich B, Tahi H and Serraj R (2005). Effects of partial rootzone drying (PRD) on adult olive tree (*Olea europaea*) in field conditions under arid climate: I. Physiological and agronomic responses. Agri., Ecos. & Envir., 106(2-3), 289-301. http://doi.org/10.1016/j.agee.2004.10.015

Wang H, Liu F, Andersen MN and Jensen CR (2009). Comparative effects of partial root-zone drying and deficit irrigation on nitrogen uptake in potatoes (*Solanum tuberosum* L.). Irrig. Sci., 27(6), 443-448. https://doi.org/10.1007/s00271-009-0159-y

Wang Y, Liu F, Jensen LS, Neergaard A and Jensen CR (2013). Alternate partial root-zone irrigation improves fertilizer-N use efficiency in tomatoes. Irrig. Sci., 31, 589–598. https://doi.org/10.1007/s00271-012-0335-3

الملخص العربى

المحافظة على المياه وتحسين إنتاج أشجار الكمثرى الليكونت باستخدام تقنية التجفيف الجزئي لمنطقة الجذور جنبًا إلى جنب مع المواد المضادة للنتح وتغطية التربة بالبولى إيثلين

محمد عبد العزيز عبد المحسن

قسم بساتين الفاكهة – كلية الزراعة – جامعة القاهرة – مصر

تعتبرندرة مياه الري قضية رئيسية تقلل من إنتاجية المحاصيل البستانية. لذلك يجب بذل الجهود لتحسين تقنيات الري وتقنيات إدارة الري واستخدام المواد الموفرة للمياه. ونتيجة لذلك ، فإن الهدف من هذا البحث هو تقليل التأثير السلبي لتقليل الاحتياجات المائية على انتاج وجودة ثمار أشجار الكمثرى "Le–Conte" تحت ظروف التربة الصحراوية. حيث تم استخدام تقنية التجفيف الجزئي للجذور partial root drying technique (PRD) ، وكذلك المواد المضادة للنتح إلى جانب تغطية سطح التربة بالبولى إيثيلين، ففى خلال مواسم الدراسة ، تم ري الأشجار بتقنية PRD بمستويات ٧٥ أو ٥٠ ٪ من أحتياجات الري (IR) irrigation requirement دون أي إضافات ، أو إضافة للرش بالكاولين أو green miracle كمضاد للنتح ، أو بتغطية سطح التربة بالبولي إيثيلين الأسود بالإضافة لمعاملة الكنترول وهى بنسبة ١٠٠٪ من IR بالطريقة التقليدية.

أظهرت النتائج أنه في ظل نظام الري بالتنقيط ، يمكن المحافظة على المياه عن طريق تقليل كميات الري بنسبة ٢٥٪ من المعدل الأمثل باستخدام تقنية PRD ، خاصة عندما يقترن باستخدام التغطية أو استخدام مواد مضادة للنتح ، وأعطت نتائج متفوقة أو مشابهة لتلك التي تم تحقيقها باستخدام معدل الري الكامل بالطريقة العادية دون أي معاملات إضافية للصفات المدروسة مثل المحتوى الكلي للمغذيات الكلية للأوراق ، ومحتوى الكلوروفيل الكلي ، والكربوهيدرات ، ومحتوى IAA و GA3 الذي حقق أعلى محصول مع أفضل خصائص للثمار من حيث وزن الثمرة ونسبة جيدة من الثمار ذات الخد الاحمر.

الكلمات المفتاحية: الليكونت ، أشجار الكمثرى ، ترشيد المياه ، تقنية التجفيف الجزئي ، مواد مقاومة النتح ، التغطية بالبولى إيثيلين.