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Effect of partial root zone irrigation on gas exchange parameters of guava

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Abstract
Guava is an important fruit crop all over the world, but water scarcity limits the production of guava. This study was conducted to investigate the gas exchange parameters like photosynthetic rate, stomatal conductance, transpiration rate and leaf temperature. The experiment was carried out in guava orchard with three irrigation treatments i.e. I_1-Control, I_2- 100% PRD and I_3-50% PRD and five varieties i.e. V_1-Swetha, V_2-Allahabad Safeda, V_3-Hisar Safeda, V_4-Lalith and V_5-Thailand constituting totally fifteen reatments. Irrigation was given at weekly once. The treatment were applied before flowering and readings were taken using Portable photosynthesis system. There was significant differences between the irrigation treatments in photosynthetic rate with higher in I_2V_5 and lower I_3V_5. There was significant differences in stomatal conductance also with lower in I_3- 50% PRD irrigation and higher in control. Transpiration rate was significantly lower in I_3 and in Control it was higher. There was no significant difference in leaf temperature in different irrigation treatments. The use of PRD 50% reduced the photosynthetic rate, stomatal conductance and transpiration rate in guava trees.

Keywords: PRD, irrigation, varieties, transpiration, photosynthesis, stomatal conductance

Introduction
Guava (*Psidium guajava* L.) is one of the major fruit crops of the tropical and sub-tropical zones in all parts of the world. It ranks 4th in area and production after mango, banana and citrus. It is a member of the Myrtaceae family. Usually, Guava is irrigated by conventional method such as overflow irrigation, basin irrigation and drip irrigation where we end up in less water use efficiency. Drip irrigation has favoured reduction in water usage by providing the water straight to the root zone of the tree but still more precise amount of water can be irrigated by adoption of partial root irrigation technique in guava.

PRD is the one of the strategies where half of the roots are irrigated and the other part should be dry left. The wet and dry soils of the root system are alternated on a time cycling (Intrigliolo and Castel, 2009; Kang *et al*., 2000; Hutton and Loveys, 2011and Console *et al*., 2014). Fruit trees might be more suitable for the application of alternate partial root zone irrigation technology because of their deeper root system and wider spacing (Du *et al*., 2005). Yield and water use efficiency are positively correlated at certain growth stages, if irrigation amount of alternate partial root zone irrigation satisfies the water requirement (Console *et al*., 2014).

One of the arrangements for reducing water footprints and saving available water resources for agriculture is to minimize the amount of irrigation water (deficit irrigation techniques) compared to the amount used for full irrigation of crops. So, partial root-zone drying (PRD) is used to minimize the amount of irrigation and it is based on the knowledge of crop's reactions to drought (FAO, 2002). The objective of this work is to study the effects of partial root zone irrigation on gas exchange parameters in guava.

Materials and Methods
Study area
The field trail was conducted at College orchard, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore and it was located at 83' N latitude, 76°71' E longitude and 426.5 m elevation above the mean sea level. The experiment was conducted between December 2018 and April 2019. The recorded mean maximum and minimum temperatures during the study period were 37.5 ºC and 16.3 ºC respectively. The recorded mean maximum and minimum evapotranspiration rates were 8.0mm and 5.1mm.

Treatment and experimental design

In this experiment, two factors involved i.e. varieties and irrigation treatments. In partial root zone plots laterals were placed on both sides of the plants alternately with one emitter (8LPH). The experimental design adopted for the study was Split Plot Design with two replications, varieties in main plot and irrigation treatment in sub plot.

Varieties (Main plot)

1. V_1- Swetha
2. V_2- Allahabad Safeda
3. V_3- Hisar Safeda
4. V_4- Lalith
5. V_5- Thailand

Irrigation (Sub plot)

1. I1- Control
2. I2- 100% PRD
3. I3- 50% PRD

The amount of irrigation water was calculated through Pan Evaporation method (Mane *et al*., 2006).

$$V = \frac{CA(m^2) \times PE \times P_C \times K_C \times PWA}{E_U}$$

Where,
V = Volume of water required (l/day/plant)
CA = Crop area (m^2)
PE = Maximum pan evaporation (mm/day)
PC = Pan co-efficient (0.70)
KC = Crop co-efficient (0.75)
PWA = Percentage wetted area (0.75)
EU = Emission uniformity, decimal
Irrigation time is the ratio between volume of water applied to the plant and discharge rate.

Gas exchange parameters observed

Leaf gas exchange parameters were measured using Portable Photosynthetic System (PPS-Licor Inc. Lincoln, Nebraska, USA Model LI-6400) equipped with a halogen lamp (6400 02B LED) on the cuvette. Narrow leaves were inserted in a leaf chamber of 3.0 cm and photons / m2/s of PPFD 1200 µ mol and 50-55 percent relative humidity was set.

1. Photosynthetic rate (µ mol CO_2 m^2/s)

Photosynthetic rate was taken in the 3rd leaf from the top of the five randomly selected plants, the mean value was calculated and expressed Pan in µ mol CO_2 m^2/s.

2. Transpiration rate (m mol of H_2O $m^{-1}s^{-1}$)

Transpiration rate was taken in the 3rd leaf from the top of the five randomly selected plants, the mean value was calculated and expressed E in m mol H_2O m^2/s.

3. Stomatal conductance (cm s^{-1})

Stomatal conductance was measured in the 3rd leaf from the top of the five randomly selected plants, the mean value was calculated and expressed gas in cm s^{-1}.

4. Leaf temperature (ºC)

Leaf temperature was measured in the 3rd leaf from the top of the five randomly selected plants using Infrared thermometer, the mean value was calculated and expressed in (ºC)

Results and discussion

1. Photosynthetic rate (µ mol CO_2 m^2/s)

The data recorded on photosynthetic rate (µ mol CO_2 m^2/s) during the two months study after irrigation in guava are given in Table1.

Among the different irrigation's treatments, I_1-Control has recorded the higher value (9.64 µ mol CO_2 m^2/s) and I_3- 50% PRD has the recorded the lower value (7.41 µ mol CO_2 m^2/s).

Among the different varieties, Variety Swetha (V_5) has recorded the higher value (9.52 µ mol CO_2 m^2/s) and the lower value was recorded in variety Lalith (V_2) (6.99 µ mol CO_2 m^2/s).

Regarding interaction effect between the irrigation treatments and varieties, I_1V_1 significantly recorded higher photosynthetic rate (11.59 µ mol CO_2 m^2/s) when compared to other combinations. However, it is on par with the treatment I_1V_3. Other treatment combinations have no significant difference in photosynthetic rate. I_3V_3 recorded lower photosynthetic rate (4.95 µ mol CO_2 m^2/s).

Dos Santos *et al.* (2003) [6] and Tang *et al.* (2005) [17] reported that the leaf area index was higher in untreated control than in the partial root zone irrigation. PRD had resulted in reduction of leaf vegetative growth. Lo Bianco *et al.* (2012) [13] also observed a similar trend.

Table 1: Effect of partial root zone irrigation on Photosynthetic rate (CO_2 m^2/s)

Treatment	V_1	V_2	V_3	V_4	V_5	Mean
I_1	11.59	8.64	10.96	9.05	7.95	9.64
I_2	9.41	9.68	7.98	6.9	7.89	8.37
I_3	7.55	7.39	4.95	5.02	5.71	6.12
Mean	9.52	8.57	7.96	6.99	7.18	
	I	V	I at V		Vat I	
SED	0.37	0.14	0.85		0.71	
CD (0.05%)	0.85*	0.38*	1.89*		1.59*	

NS - Non-significant *-Significant

Stomatal conductance (cm s^{-1})

The data recorded on stomatal conductance (cm s^{-1}) two months after application of partial root zone irrigation in guava are given in table 2.

With regard to different irrigation treatments, the effect was found to be non-significant.

Among the different varieties, variety Thailand (V_5) has recorded higher value (0.16 cm s^{-1}) whereas the lower values were recorded by Allahabad Safeda (V_2) and Hisar Safeda (V_3) (0.03cm s^{-1}).

With regard to the interaction effect between irrigation treatments and varieties the higher values of stomatal conductance was recorded by I_1V_5 (0.16 cm s^{-1}). I_3V_2 and I_3V_3 treatment combinations recorded the lower stomatal conductance (0.03 cm s^{-1}).

In our study partial root zone irrigation reduced the stomatal conductance and increased the leaf water use efficiency in guava, which is in agreement with the previous results on grapevine (Dry *et al*., 1996, 2000a, b; Dry and Loveys, 1998; Loveys *et al*., 1998 and Stoll *et al*., 2000) [16].

Table 2: Effect of partial root zone irrigation on Stomatal conductance (cm s^{-1})

Treatment	V_1	V_2	V_3	V_4	V_5	Mean
I_1	0.13	0.06	0.09	0.14	0.16	0.11
I_2	0.10	0.12	0.10	0.12	0.10	0.10
I_3	0.07	0.03	0.03	0.04	0.07	0.04
Mean	0.09	0.07	0.07	0.10	0.10	
	I	V	I at V		Vat I	
SED	0.01	0	0.02		0.15	
CD (0.05%)	NS	0.01*	0.08*		0.03*	

NS - Non-significant *-Significant

Transpiration rate (m mol of H_2O $m^{-1}s^{-1}$)

The data recorded on transpiration rate due to the influence of irrigation treatments and varieties are presented in Table 3.

With regard to different irrigation treatments, I_1- Control recorded the higher value (7.03 m mol of H_2O $m^{-1}s^{-1}$) when compared to other irrigation treatments. I_3- 50% PRD recorded the lower value (4.46 m mol of H_2O $m^{-1}s^{-1}$).

With regard to different varieties, variety Thailand (V_5) recorded higher value (7.90 m mol of H_2O $m^{-1}s^{-1}$) compared to other varieties. While variety Swetha (V_2) had recorded lower value (4.62 m mol of H_2O $m^{-1}s^{-1}$).

Effect of interaction between irrigation treatments and varieties brought out a significant influence, I_1V_5 recorded the higher transpiration rate (11.18 m mol of H_2O $m^{-1}s^{-1}$). I_3V_2 recorded lower transpiration rate (2.56 m mol of H_2O $m^{-1}s^{-1}$).

Santos *et al*. (2013) [15] reported that plants under water deficit reduced the transpiration rate in leaves to avoid water loss. Castro Neto. (2003) [1] also opined that plants reduce the transpiration rate to reduce loss of water and maintain soil moisture level.

Table 3: Effect of partial root zone irrigation on transpiration rate (m mol of H_2O $m^{-1}s^{-1}$)

Treatment	V_1	V_2	V_3	V_4	V_5	Mean
I_1	6.16	4.10	5.40	8.30	11.18	7.03
I_2	6.29	7.20	7.15	1.78	7.12	5.91
I_3	6.06	2.56	3.73	4.54	5.39	4.46
Mean	4.63	4.62	5.43	4.87	7.90	
	I	V	I at V		Vat I	
SED	0.40	0.44	0.80		0.78	
CD (0.05%)	1.76*	0.98*	2.20*		1.69*	

NS - Non-significant * - Significant

Leaf temperature (ºC)

The data recorded on leaf temperature after one month of application of PRD is presented in Table 4.

Different irrigation treatments had significantly influenced the leaf temperature. I_3- PRD 50% had recorded the higher value (36.08 ºC) compared to other irrigation treatments. I_1- Control had recorded lower value of leaf temperature (33.02 ºC). Among the different varieties, Hisar Safeda (V_3) recorded the higher leaf temperature (37.10 ºC) compared to other varieties and Lalith (V_4) recorded lower value (37.07 ºC).

With regard to interaction effect between irrigation treatments and varieties, I_3V_3 had recorded higher value (36.80 ºC). I_1V_2 had recorded lower value (29.40 ºC).

Thus, in our experiment, the leaf temperature was found higher recorded in 50% PRD and lower in control.

Table 4: Effect of partial root zone irrigation on Leaf temperature (ºC)

Treatment	V_1	V_2	V_3	V_4	V_5	Mean
I_1	34.25	29.40	32.90	34.70	33.85	33.02
I_2	35.20	33.95	35.60	34.55	34.40	34.74
I_3	35.75	36.20	36.80	35.05	36.60	36.08
Mean	35.07	33.18	35.10	34.77	34.95	
	I	V	I at V		Vat I	
SED	1.09	1.06	1.97		1.83	
CD (0.05%)	4.67*	2.30*	5.56*		3.99*	

NS - Non-significant * - Significant

Conclusion

The present study has attempted to assess the effectiveness of PRD. PRD offers an advantage over conventional irrigation when water supplies are limited because it helps to reduce water use during period of evaporative demand by utilizing the changed relationship between stomatal conductance and transpiration rate demonstrated in PRD response.

References

1. Castro Neto. Efeito do déficit hídrico na transpiração e resistência estomática da mangueira. Revista Brasileira de Fruticultura. 2003; 25:93-95.
2. Consoli S, Stagno F, Roccuzzo G, Cirelli G, Intrigliolo F. Sustainable management of limited water resources in a young orange orchard. Agric. Water Manage. 2014; 132:60-68.

3. Dry PR, Loveys BR, Botting D, During H. Effect of partial root zone drying on grapevine vigour, yield, composition of fruit and use of water. In: Proceedings of the Ninth Australian Wine Industry Technical Conference, 1996.
4. Dry PR, Loveys BR, Ring H. Partial drying of the root-zone of grape. I. Transient changes in shoot growth and gas exchange. Vitis. 2000a; 39:3-7.
5. Dry PRBR Loveys. Partial drying of the root-zone of grape. II. Changes in the pattern of root development. Vitis. 2000b; 39:3-7.
6. Dos Santos TP, Lopes CM, Rodrigues ML, De Souza CR, Maroco JP, Pereira JS *et al*. Partial root zone drying: effects on growth and fruit quality of field-grown grapevines (*Vitis vinifera*). Fun ct. Plant Biol. 2003; 30(6):663-671.
7. Du TS, Kang SZ, Hu XT, Zhang FC, Gong DZ. Research progress of alternate partial root zone irrigation on fruit tree. Trans. Chin. Soc. Agric. Eng. 2005; 21(2):172-178.
8. FAO. Deficit Irrigation Practices. Water Reports Rome. 2002; 22.
9. Hutton RJ, Loveys BR, A partial root zone drying irrigation strategy for citrus effects on water use efficiency and fruit characteristics. Agric. Water Manage. 2011; 98:1485-1496.
10. Intrigliolo DS, Castel JR, Response of *Vitis vinifera* cv 'Tempranillo' to partial root zone drying in the field: water relations, growth, yield and fruit and wine quality. Agric. Water Manage. 2009; 96:282-292.
11. Kang SZ, Liang Z, Pan Y, Shi P, Zhang J. Alternate furrow irrigation for maize production in an arid area. Agric. Water Manage. 2000; 45(3):267-274.
12. Loveys BR, Stoll M, Dry PR, McCarthy M. Partial root zone drying stimulates stress responses in grapevine to improve water use efficiency while maintaining crop yield and quality. Aust. Grape grower Winemaker. 1998; 414:108-114.
13. Lo Bianco R, Talluto G, Farina V. Effects of partial root zone drying and rootstock vigour on dry matter partitioning of apple trees (*Malus domestica var* Pink Lady). J Agric. Sci. 2012; 150(1):75-86.
14. Mane MS, Ayare BL, Magar SS. In: Principles of drip irrigation system. Jain Brothers, New Delhi, 2006, 24-87.
15. Santos MR, Martinez MA, Donato SLR. Gas exchanges of "Tommy Atkins" Mango Trees under Different Irrigation Treatments. Bioscience Journal. 2013; 29:1141-1153.
16. Stoll M, Loveys BR Dry PR. Hormonal changes induced by partial root-zone drying of irrigated grapevine. J Exp. Bot. 2000; 51(350):1627-1634.
17. Tang LS, Li Y, Zhang JH. Physiological and yield responses of cotton under partial root zone irrigation. Field Crops Res. 2005; 94(2-3):214-223.