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Partial Root Zone Drying Technique: Water Conservative Approach for Dry Land Cultivation of Fruit Crops

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SUMMARY

Partial root zone drying technique is a novel water saving irrigation technique used in arid and semi-arid conditions. This technique is mainly implemented for increasing irrigation water use efficiency and water productivity as compared to fully irrigated crop plants in areas where water resources are limited. Though PRD has not significantly affected the yield and quality attributes of fruits as compared to fully irrigated fruit crops, but still found as a remedy for the orchards of dry land.

INTRODUCTION

Continuous changing climate is the major obstacle in sustainable production of food for society. This change is majorly attributed by erratic rainfall and other biotic factors such as incidence of various pest and diseases. Drastically lowered rainfall leads to drought like condition in many regions of the country. Water is the key component through which plant takes nutrients with the help of the well-developed root system. In the absence ofwater, nutritional elements that found in soilcan be used with difficulty from the root. Frequent occurrence drought like conditions hampers agricultural productions which includes food grains, oil seed crops, horticultural crops such as fruits and vegetables. To achieve sustainable production even under stressful condition different technologies, need to be adopted. Hence to achieve the target offood security for 8 billion people by the end of2025, irrigated area should be increased bymore than 20% and the irrigated crop yieldshould be increased more than 40% (Lascano et al. 2007). Partial Root Zone Drying is one of the best technologies implemented for orchards belonging to water scarcity zones. This PRD technique is being practised for 10 years as better irrigating technique for dry land. In this method, one-half of the root system is forced into a drying phase while the other half is in irrigated phase (Kang and Zhang, 2004). This cycle should be altered after 10-15 days of treatment. This method was firstly implemented in cotton field (country – USA) by Grimes *et al*.in 1968.

Deficit irrigation methods

Wetting and drying of roots are dependent on crops, growing stage, evaporative demands, soil texture and soil water balance (Saeed et al., 2008). Practically, PRD can be used in different ways depending on the cultivated crops and/or soil conditions, environmental conditions and method of irrigation most commonly used are seven, fourteen and twenty days. The dryness on one side leads to a decrease of plant transpiration without exhibiting symptoms of severe stress.

How does PRD work

- When part of the rootzone dries out
- Increases levels of abscisic acid (ABA) in the plant
- Close the stomata with response to water stress
- Reducing shoot growth and transpiration from the leaf surface
- Alternating the wet and dry zones of the roots
- Repeated surges of ABA are delivered to the shoots
- No significant effects on flowering and fruit development.

Mechanism of PRD

Mechanism of PRD effects on crop growth, therefore, no definite solid procedure exist on determining the optimum timing of irrigation for each side. Kriedmann and Goodwin (2003) indicated that when soil water extraction from dry side is negligible, wetting should be changed from irrigated side to non-irrigated side. Furthermore, Liu et al. (2008) stated that switching should be based on threshold soil water content in which the

maximum xylem abscisic acid (ABA) concentration is produced. ABA is a plant hormone that is produced in the roots in drying soils and is transported by water flow in xylem to the shoot for regulating the shoot physiology (Kang and Zhang, 2004).Therefore, in PRD roots sense the soil drying and induce ABA that reduce leaf expansion and stomatal conductance and simultaneously the roots in wet soil absorb sufficient water to maintain a high water status in shoot (Zegbeet al., 2006; Liu et al., 2006; Ahmadi et al., 2010).

Water stress

Roots in drying soil produce more ABA than under normal conditions (Davies and Zhang, 1991) and it is moved as an anti-stress root chemical signal to shoot through transpiration stream and limits the stomatal conductance. A balance between CS and HS occur in PRD. In PRD, roots on the irrigated side absorb enough water to maintain high shoot water potential, and the roots on the non-irrigated side produce ABA for possible reduction in stomatal conductance. This mechanism optimizes water use and increase WP. Decrease in leaf expansion declines the use of carbon and energy, and a higher proportion of the plant assimilates is distributed to the root system and support further root development (Taiz and Zeiger, 2006). At mild water stress, ABA as a major chemical signal (CS) acts earlier than the change in plant water status (hydraulic signal, HS). However, under severe water stress, both CS and HS may be involved in regulating plant physiological processes (Ali et al., 1999). In some plants CS and HS occur independent of each other, while in others they take place dependently.

Tips for implementing PRD

- Best PRD responses occur in soils with high values of readily availablewater (RAW)
- PRD should not be use in soils with poor in filtration characteristics.
- The amount and timing of irrigation applied to the ‘wet’ side should be sufficient.
- The irrigated side of the plant should be switched when water extraction from the “dry” side becomes negligible.
- Correctly implemented PRD should not result in major effects on fruit quality.

Different ways for PRD application

- Controlled alternate drip irrigation
- Controlled alternate furrow irrigation (AFI)
- Controlled alternate surface irrigation
- Controlled alternate sub surface irrigation

Advantages of PRD technique

- Increases water use efficiency
- Increases the nutrient uptake
- Reduces transpiration rate
- Reduces excessive vegetative growth
- Improves fruit quality without reducing the crop level
- Drought tolerant deciduous plants respond best to PRD

Limitations of PRD

- Cost of implementing PRD irrigation system is high compared with traditional systems
- Lack of experiences about implementation of PRD irrigation system
- It does not responses well to shallow soils with low readily available water (RAW)
- PRD response is varying with species
- Lack of awareness about PRD irrigation method

PRD method used in Grape crop

In grape cultivation, the quality of grapes is depending on water availability. So, water play an important role in grape production. In water scarcity and drought condition we can manage the water problem by using PRD system of irrigation which increases water used efficiency of grape vine without affecting their quality and quantity. We conducted an experiment with two treatments 1) full irrigation and 2) PRD 50% of irrigation system on grapevine and the result we get is no significant yield reduction in partial root-zone drying areas of grapes vine. (Bindon et al., 2008)

Table: Effect of different partial root-zone drip irrigation on yield components and water use efficiency of grape cv. Rizamat.

Parameter	PRD	RDI	CDI
Bunch number / tree	25.30	23.50	19.75
Berry number / bunch	66.08	50.56	57.80
Bunch weight (g)	355.82	360.22	445.0
Bunch volume (cm^3)	339.88	323.23	415.82
Edible grape (%)	94.25	93.23	90.37
Yield (kg/tree)	8.94	8.40	8.83
Yield (t/ha)	17.30	16.25	17.08
WUE ETc (kg/m^3)	7.11	5.61	5.31
TSS (^{0}Brix)	13.65	13.10	13.17
TSS: acid ratio	58.58	53.04	56.52

Taisheng et al. (2008)

PRD method used in pomegranate crop

Pomegranate fruit crop is widely cultivated under tropical and sub-tropical regions. In pomegranate, long irrigation spell and sudden irrigation leads to fruit cracking. So, to overcome this problem PRD system of irrigation is effectively used. By comparing the PRD irrigation system with 100% irrigation system, we found that maximum fruit weight, fruit diameter, aril weight, juice percentage, TSS, pH, and minimum fruit cracking and titratable acid recorded in PRD treatment as compare to 100% irrigation treatment. (Noitsakis et al., 2016)

PRD method used in citrus crop

By using PRD method of irrigation system in citriculture can save up to 25- 40% water. And significantly higher yield and less fruit drop was found under treatment of PRD 60% irrigation method. (Lovatt and Faber 2007)

Future prospects

- PRD irrigation is in the research phase further experience areneeded to evaluate economic advantages.
- Further research is needed to see the effect of PRD on yield and fruit quality gives the same results in both dry and humid climate.
- Use of PRD under lateral move irrigators in combination with LEPA (low – energy precision – application).
- With an increasing demand for newer cultivars, higher density anddifferent canopy architecture.

CONCLUSION

Partial root-zone drying irrigation (PRD) is the novel deficit irrigation strategy that is majorly adapted for fruit crops belonging to dry land agriculture. Key objective of this technique to improve water productivity under depleting soil moisture conditions. Though, the amount of saved irrigation water and improved water productivity strongly depends on crop, soil, and site specifications.

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