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Regulated deficit irrigation (RDI) in fruit crops – Grow quality fruit with minimum water

Among several environmental stresses, deficient water status is a major concern over the world and impacts a lot on growth of plant thereby ultimately on yield and quality of the produce. This impact of water stress is equally significant on fruit crops as on other crops. But, to ensure food and nutritional security for ever increasing world population, the regulated deficit irrigation (RDI) in fruit crops will be the best alternative to grow quality fruit with minimum water facility which will tackle the water deficit in a positive manner and reduce irrigation amounts or increase the water-use efficiency. With the above background, RDI will result in significantly increased coping with several stress situations as with our present concern of the water deficit.

IN the last two decades, several approaches and strategies were developed and recommended; to tackle the situation of water deficit in different crops; among them, several deficit irrigation options are considered very much effective. Regulated Deficit Irrigation (RDI) is one such of the deficit irrigation options, that is generally conceptualized as an irrigation practice whereby a crop is irrigated with an amount of water below the full requirement for optimal plant growth. This is to reduce the amount of water used for irrigating crops, improve the response of plants to the certain degree of water deficit in a positive manner, and reduce irrigation amounts or increase the crop's water-use efficiency (WUE). RDI also refers to any irrigation strategy that maintains plants at some degree of water deficit for a prescribed part (or parts) of the season, aiming to control reproductive growth and development, vegetative growth and/or improve water-use efficiency.

Principle and methodology behind success of RDI

Water deficit induced root sourced chemical signals such as ABA are more susceptible to water shortage than photosynthesis and fruit growth, according to RDI. Fruit trees deal with a lack of water by limiting transpiration (stomata control or reducing leaf surface area by reducing leaf development). Fruit tree sensitivity to water deficit varies throughout the growing season, and a water deficit during specific periods may benefit water productivity by boosting irrigation water savings, minimising or eliminating negative yield and crop revenue impacts, and even improving harvest quality.

As a result, when an RDI method is used, full irrigation is provided during the drought-sensitive phenological phases (critical times) of fruit trees, whereas irrigation is curtailed or even eliminated during the drought-tolerant phenological stages (non-critical periods) which improves water savings and even harvest quality, reduces excessive vegetative vigour. It can be scheduled using only trunk diameter sensors and could be operated in furrow or drip-irrigated fruit trees.

Scheduling of RDI

Under trickle irrigation, the original recommendation for scheduling RDI was to irrigate daily and calculate irrigation amount from a percent replacement of Epan. The formula used to calculate irrigation run time is:

$$\text{Run time (h)} = \frac{(E_{pax} - \text{Rain})\ (mm) \times \%\ \text{Replacement} \times \text{Row spacing (m)} \times \text{Tree Spacing (m)}}{\text{Emitter rate per tree (litres/h)}}$$

Mitchell and Goodwin (1996) recommended a formula based on average daily pan evaporation for estimating irrigation interval for systems other than trickle:

$$\text{Interval (days)} = \frac{\text{Volume of water in rootzone (litres)}}{\text{Average daily water use (litres/day)}}$$

where volume of water in rootzone (litres) = width of wetted strip (m) × tree spacing (m) × 0.3 m wetting depth (m) × soil type factor ranging from 60 (sandy soils) to 80 (loams and clays); average daily water use (litres/day) = row spacing (m) × tree spacing (m) × replacement factor × average daily Epan (mm).

Easy implementation of RDI at farmer's orchard

A successful RDI installation in fruit orchards requires several essential considerations that are not typically taken into account. These include precise identification of water stress-sensitive phenological stages, a thorough understanding of physiological responses to water stress,

Well-grown one-year-old sweet orange cv. Malta with (DIT): 70% of reference evapotranspiration

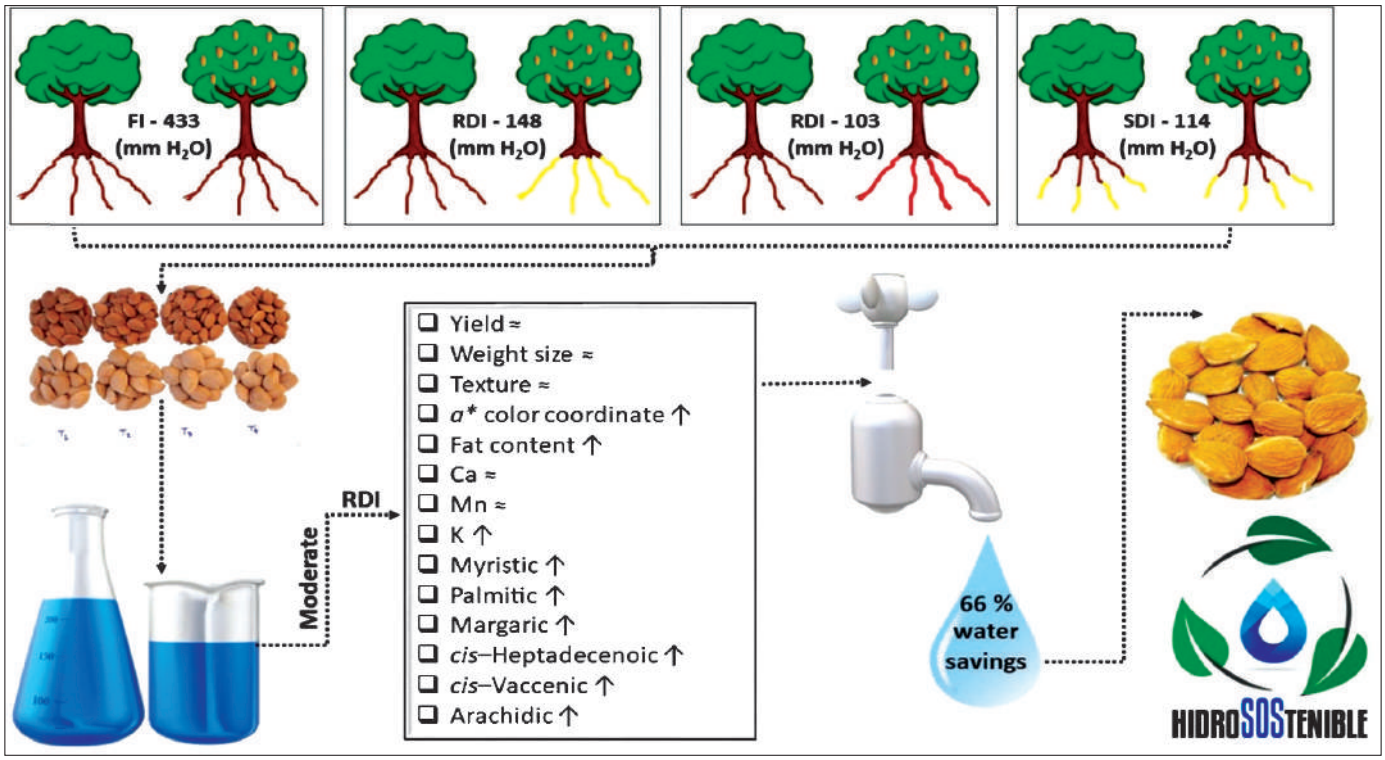
RDI experiment field of dragon fruit at establishment stage

and reliable approach for measuring orchard water requirements and plant water status throughout the season. Water stress-sensitive periods varied among fruit crops, making precise identification of essential dates to apply RDI. The irrigation scheduling (especially at vegetative growth and reproductive growth stages), adopting practices such as conservation tillage and installing more efficient irrigation systems like sprinkler and drip irrigation systems are more efficient than furrow irrigation. The government of India under PMKSY is providing subsidy to establish different micro-irrigation facilities at farmers field at about 90% subsidies which directly reduce the excess water demand and it improves fruit quality by which farmers will get remunerative profit.

Promotional opportunities of RDI in India

In last 2-3 years, most of the agriculture institute as well as selected KVKs (Krishi Vigyan Kendras) are provided with facility of the District Agromet Unit (DAMU) which is a project under the scheme *Garmin Krishi Mausam Seva* (GKMS), a joint initiative between Ministry of Earth Science and Ministry of Agriculture, to cater all sorts of information and forecast weather data in time for avoiding losses of crop from uncertainties of natural aberrations. Thus, research on crop specific RDIs for specific region is now a priority area. As government is promoting precision agriculture to reduce input cost through minimizing wastage of resources, farmers should install micro-irrigation system in their orchard availing support of govt subsidy schemes like *Per Drop More Crop* element of PMKSY (*Pradhan Mantri Krishi Sinchayee Yojana*) where about 90% subsidy is available. After that, during scheduling of irrigation, they should consult nearby agri-clinic or organization for assistance regarding fixing RDI strategies for specific crop. In West Bengal, condition deficit irrigation treatments-(DIT): 70% of reference evapotranspiration for a one-year-old sweet orange cv. Malta has revealed best regarding all growth parameters. Similarly, for banana and dragon fruit also, experiment is going on in this regard.

Semiarid areas have potential for RDI technology due to longer and more intense drought periods, produced by climatic change, and an increase in the demand for water. As we know that Bundelkhand region of India has a huge potential for citrus cultivation that require more water, in that case, RDI would appear to be an alternative that might become necessary for this region which gives good adaptability.



Improved almond nut quality through regulated deficit irrigation (RDI)

Table 1. Successful reports of RDI in different fruit crops as mentioned by Galindo *et al*. (2018)

Crop	RDI strategies
Mango (*Mangifera indica* L.)	Sustained deficit irrigation at 50% Etc proved to be the most appropriate treatment, since it allowed the trees to reach the highest yield (18.4 t/ha) and the best water-use efficiency (7.14 kg/m^3).
Citrus (*Citrus sinensis* L. Osbeck)	Water restriction during summer, and once «June drop» has finished, favours the better use of water resources by Navelina citrus trees, achieving an increase of water-use efficiency (between 14%-27%), provided that an appropriate irrigation in autumn allows for tree recovery.
Grape (*Vitis vinifera* L.)	RDI_1 with a deficit period just after fruit-set (irrigation withheld until *pd* reached −0.8 MPa) and in RDI_2 with an additional milder stress period just after veraison (until *pd* reached −0.6 MPa), harvest quality has been clearly improved in grape.
Jujube (*Zizyphus jujuba* Mill.)	Jujube fruit maturation can be advanced, and the fruit yield and quality enhanced if appropriate RDI is applied at certain growth stages (bud burst to leafing and fruit maturation) only with 360 mm of irrigation water.
Loquat (*Eriobotrya japonica* Lindl.)	Complete suppression of watering from around one month after the end of previous harvest (early June) up to reach a ψ_{stem} value circa – 2.2 MPa (8–9 weeks), because do not alter the formation of the floral organs and increase the advancement of bloom next season, while prolonging the water deficit period during one additional month (August) may impair flower development in loquat.
Pomegranate (*Punica granatum L.*)	Irrigation water restriction during pomegranate fruit growth and ripening enhances peel redness and TSS in the juice. However, restricting the irrigation water during the linear fruit growth period increased the concentration of many bioactive compounds in the juice, such as anthocyanins.
Pistachio (*Pistacia vera* L.)	RDI using a ψ_{stem} threshold value of −1.5 MPa during stage II induced similar yield and production values to full irrigated trees. RDI trees (receiving 50% of the water received by control trees during stages I and II, and the same amount of water as control trees during stage III) provided a similar total yield and percentage of split nuts as full irrigated trees and did not show an alternate bearing pattern, even though they received around 20% less water.

Source: Lipan *et al*. (2019)

SUMMARY

Research on scheduling RDI strategies among different fruit crops is still on-going over the world. But major research findings suggest its positive impact to mitigate water stress maintaining the consumer preferable quality as well. Thus, in countries like India where a major portion of fruit belt lies in water deficient states, should encourage different RDIs to produce optimum quality fruit utilizing available water.

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