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A review on effect of drip irrigation under ultra-high density planting system (UHDPS) of guava (*Psidium guajava* L.)

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Abstract
Ultra high density planting system increases production, productivity and improves fruits quality and it helps to improve efficient use of land, water, light, fertilizers and pesticides, which are frequently lost in traditional planting systems. At present, there is need to replace the traditional planting and irrigation systems with the improved high density planting and drip irrigation system. UHDP is a highly efficient and advanced production system of fruit cultivation in which optimum growth and fruit production is strongly linked with drip irrigation water. The Reviews indicated the necessity for better understanding and utilization of tree physiological parameters for management of irrigation water of guava fruit crops. This will ultimately lead to achieving optimum plant growth, yield and fruit quality, and maximum water use efficiency while conserving water and land resources.

Keywords: Drip irrigation, growth, yield, quality and water use efficiency

Introduction

Guava (*Psidium guajava* L.) is the most valuable cultivated species of the Myrtaceae family, originated from tropical America and is presently cultivated in many tropical and subtropical area of worlds (Cobley, 1976; Samson, 1986; Morton, 1987) [1-3]; belongs to Myrtaceae family and popularly known as “apple of tropics” (Nakasone and Paull, 1998) [4] and “poor man’s fruit” due to cheapness and high nutritive value in addition to its availability in the market (Kumar *et al.,* 2009) [5]. Due to its growth habit it provides opportunity for planting more number of plants in per unit area and harvesting maximum yield from per unit area by providing proper pruning technologies and efficient nutrient and water management facilities (Mehta *et al*., 2012) [6]. The system of orcharding having more number of plants per unit area and high yield (Bryla and Dhaliwal, 2003, Rajput *et al*. 2004) [7, 8] than that is planted under traditional system of planting is called high density orcharding. or it also can be say that ultra-high density orcharding is a system of planting the plants at a closer spacing (1m x 2m) in order to accommodate relatively larger number of plants per unit area (5000 plants/ Ha) (Mehta *et al.,*2012) [6]. High density/Ultra high density planting not only provide high yield but also facilitate for efficient utilization of land, water and sunlight (Reddy, 2014) [9].

Drip irrigation is the most efficient and advanced technology, which offers great promise due to its higher water and nutrient use efficiency by crops against lower amounts of water, applied and avoids moisture stress throughout the growing period by providing available moisture at critical crop growth stages (Kumar *et al*., 2005 and Raina *et al*., 2011) [10, 11]. Depending upon soils and weather conditions this system can save upto 40-70% of water and increase crop productivity by 10 to 55% (Bread *et al*.. 1998; Deshmukh and Sen, 2000) [12, 13]. Many researchers have reported the higher application efficiency of drip irrigation systems over the conventional basin irrigation systems (Salvin *et al*., 2000; Bharambe *et al*., 2001; Agrawal and Agrawal, 2007) [14, 15, 16] compared to drip and basin irrigation systems in fruits and found that there was savings of 40 to 60% more irrigation water than basin irrigation methods. Water use efficiency is related to the output: input ratio in an agro-ecosystem, more specifically, relating the amount of biomass production to consumption by crop (Hsiao *et al*., 2007, Turner, 2004) [17, 18]. Drip irrigation in the mid1960s through mid1970s was considered an emerging technology with its application limited only to high- priced, specialty crops. Today it is used on a wide variety of crops; even those were initially considered unprofitable for management under drip irrigation. The intensive treatment of irrigation water required for the proper operation of drip irrigation system is presently an accepted practice (Nakayama and Bucks, 1991) [19]. Bucks *et al*. (1982) [20] provided a brief discussion of surface drip irrigation. Similarly, Bucks and Davis (1986) [21] discussed it in a portion of their history of drip irrigation. Water use efficiency (WUE) is defined by the ratio between the crop and the amount of water consumed by crop. The WUE indicator defined by that ratio is useful to identify the best irrigation scheduling (Zhang, *et al*. 1999) [22]. Water use efficiency (WUE) has important implications when considering irrigation, soil and water conservation, productivity, and sustainability of irrigated agriculture. WUE is usually defined as the ratio of dry matter yield (Y) per unit of water evapotranspired. Water use efficiency has been significantly improved through the use of Drip irrigation technique. Drip irrigation and fustigation are potentially controlled water and nutrient release systems Fertigation indicated in a saving of 25% irrigation water and 33% higher fruit yield compared with straight fertilization with surface irrigations. Fertigation and mulch indicated in 20% fertilizer savings and 40% water savings, besides 33% higher yields compared to conservative practices. Hence, drip fertigation in conjunction with mulch could be effectively utilized for sustainable orchard management in Himalayan region (Suman and Raina, 2014) [23]. Low-volume irrigation systems are well suited to the high-density guava orchards that are increasingly important in plateau and hill conditions. Fertigation offers increased flexibility in managing orchard nutrition programs because of the potential for more closely synchronizing nutrient application with plant demand (Haynes, 1985) [24]. The mobility of fertilizer N in response to irrigation has long been recognized for irrigated crops in humid and arid regions (Stapleton *et al*., 1983) [25]. Judicious application of water and plant nutrients in guava is pre-requisite to achieve the targeted yield and quality of fruits (Singh and Singh, 2007) [26]. Reported information varied widely content and scope, especially with regard to crop growth and fruit yield, crop water requirement and efficiencies in ultra-high density planting (UHDP) Guava orchards.

The literatures on the aspects of Ultra High Density Planting and drip irrigation in guava orchard have also been incorporated in review under following heads:

Major Response of Drip Irrigation under Ultra High-Density Guava Orcharding Vegetative Growth

Many reports have shown higher vegetative growth in drip irrigation system over the comparable conventional Irrigation method. Applications of drip irrigation significantly influence the vegetative growth of ultra-high density planting (UHDP) Guava orchards. Although, many studies reported that in drip irrigation, variation affect after five years old UHDP Guava orchard. Shanker *et al*. 2015 [27] reported that different irrigation treatments did not show significant effect on trunk girth and girth of primary Branch during both the years of experimentation. However, at the end of the second year of the experimentation highest trunk girth was observed in case of no-irrigation and water application at 80% of PE. Similar report was given which clearly indicates that Deficit irrigation System did not significantly affect the vegetative growth of peach in high density planting system (Williamson and Coston, 1990) [28]. Khattab *et al*. 2011 [29]. observed that, the highest irrigation level of 15m^3/tree/year induced vegetative growth by increasing shoot length, number of leaves per shoot and leaf area. Likewise Richards and Rowe (1977) [30] confirmed this concept by restricting the root systems of hydroponically developed peach seedlings. Root restriction resulted in reduced vegetative growth even when water and nutrients were no limiting. Removals of portions of the root systems of various plants have caused similar responses (Buttrose and Mullins, 1968; Kende, 1965) [31, 32]. Daily drip irrigation significantly improved the growth characters, *viz.*, plant height, stem diameter, number of leaves per plant, length of tap root and spread of feeding roots along with yield and yield attributes in Papaya (Jain and Tiwari**,** 2012) [33].

Ramniwas *et al*. (2012) [34] conducted experiment on effect of irrigation and fertigation scheduling on growth and yield of guava under meadow orcharding. The experiment comprised sixteen treatment combinations which included four irrigation levels (basin, 50, 75 and 100% irrigation of irrigation water/cumulative pan evaporation) along with four fertigation levels, including, basal dose, 50, 75 and 100 per cent water soluble fertilizers. They concluded that maximum plant height (2.07 m), canopy volume (1.24 m3), girth of primary branches (2.48 cm) and leaf area (66.08 cm2) were recorded with application of 100 per cent irrigation of irrigation water/cumulative pan evaporation + 100 per cent water soluble fertilizers.

Maximum plant height (3.5 m) and canopy volume (24.83 m3) were recorded with the application of irrigation through drip at 75 per cent of ET as compared to 25 and 50 per cent ET in guava cv. Sardar (Sarolia *et al*., 2010) [35].

Flowering Behaviour

Many reports have indicated that significant effect on flowering behaviour in the UHDP Guava orchard under drip irrigation system. Shanker, K. *et al*. 2015 [27] reported that different irrigation treatments showed significant effect on flowering Behaviour in UHDP guava. Similar report was given which clearly indicates that drip irrigation treatment had significant effect on Flowering Attributes in Pomegranate (Khattab *et al*. 2011) [29]. José E. Fernández *et al*., 2013 [36] reported that deficit irrigation strategy indicated the significant increased maximum number of flower in high density olive orchard. Williamson and Coston in 1990 reported that deficit irrigation System depicted significantly affects the flowering performance of peach in high density planting system. Bryla *et al*., 2003 [7] found that the significant flowering performance of young peach tree under surface drip irrigation system.

Yield Attributes

Many reports have shown higher yield in drip irrigation system over the comparable conventional Irrigation method. Applications of drip irrigation significantly increased yield attributes of ultra-high density planting (UHDP). Although, many studies reported that in own-rooted peach trees evaluated at two levels of irrigation in a high-density orchard had Significantly increased in yield performance (Williamson and Coston, 1990) [28], Maximum number of fruits per plant, fruit weight and fruit yield per plant were significantly highest with daily drip irrigation in papaya (Jain and Tiwari**,** 2012) [33], Joshi, G., *et al*, 2012 [37] found that the significant increase in fruit yield in irrigation level from Mulch + drip irrigation at 100% of estimated irrigation water requirement +75% RDF in both the years due to higher growth and nutrient status of leaves and lower fruit drops under the treatment receiving irrigation at 100% of the estimated irrigation water requirement. Khattab *et al*., 2011 [39] reported that the highest irrigation level of $15m^3$/tree/year showed increased fruit retention, yield and fruit cracking in pomegranate. Similar results were proposed by Sujatha *et al*. (2006) [38] and Dixit *et al*., (2003) [39] in mango; Zhou *et al*., (2002) [40] and Hasan *et al*., (2002) [41] in litchi. In a review, Camp *et al*., (1993) found that yield for Drip Irrigated crops were equal to or greater the yield from other method of irrigation. Khattab *et al.*, 2011 [29] observed that highest irrigation level of $15m^3$/tree/year increase number of flowering, yield and fruit cracking in pomegranate. Using irrigation level of $13m^3$/tree/year recorded the highest water use efficiency.

Quality Character

In recent time, Drip Irrigation system is getting value and popularity due to its positive results in Irrigation management and quality food produced. Many reports have indicated that improved the performance of fruit quality, Joshi, G., *et al*., 2012 [37] found that drip irrigation at 100% of estimated irrigation water requirement yielded better quality fruits having higher fruit length, fruit width, fruit weight, pulp weight, Total soluble solid, ascorbic acid and lower peel weight, stone weight and terrible acidity as compared to other levels of irrigations Due to increased cell division and elongation by an adequate nitrogen supply and simultaneous increased turgidity of cells due to K Fertigation in litchi. Klein *et al*. [42], in 1989 indicated that treatment MId3F3 i.e. with black polyethylene mulch+ drip irrigation at 100% of estimated irrigation water requirement + 125% RDF recorded better quality fruits having maximum pulp weight, Total soluble Solid, ascorbic acid content and lower peel weight, stone weight and titrable acidity. Similar reports were found in earlier studies also demonstrated better fruit quality in citrus under soil water deficit condition in root zone of plants (García-Tejero *et al*., 2010) [43]. Panigrahi, P., *et al* [44]. 2012, reveal that the application of optimum quantity of water through DI (80% Ecp) could impose desirable water stress on 'Nagpur' mandarin plants, improving their yield and fruit quality

Water Use Efficiency

Irrigation scheduling was reviewed in most reports, either in timing or amount of application or both. Method of Scheduling irrigation application was based on evapo-transpiration, Pan Evaporation, direct measurement of soil and plant properties. The water supply capacity directly affects the design and operation of drip irrigation system. The size of irrigated field or Zone is often controlled by the available capacity of water supply. Quality of water supply is extremely and significantly influences the type of water infiltration. Suman and Raina[23] in 2014 reported that fertigation resulted in a saving of 25% irrigation water and 33% higher fruit yield compared with conventional fertilization with surface irrigations. Fertigation and mulch resulted in 20% fertilizer savings and 40% water savings, besides 33% higher yields compared to conventional practices. Panigrahi, P. *et al*. [44], 2012 overall results of the present field investigation demonstrate that the adoption of optimal DI regime (80% Ecp) could save a substantial amount of irrigation water over traditional BI in 'Nagpur' mandarin cultivation. This will help in bringing more area under irrigation, resulting in higher production of quality citrus fruits. Further studies related to optimizing the quantities of NPK based fertilizers and micronutrients applied through DI system for 'Nagpur' mandarin is suggested. Drip irrigation technology permits the efficient use of water and can help to maximize the utilization of land for papaya production (Padma Kumari and Sivanappan, 1989) [45].

Conclusion

With the help of reviews mentioned above it is concluded that the application of Surface drip irrigation in Ultra High Density Planting of Guava orchard will continue to increase in the near future, depending primarily upon the economic benefits of this technology in comparison to other irrigation methods. Drip irrigation strategies are valuable tools for improving the water-use efficiency in UHDP Guava orchard, achieving significant water savings and maintaining sustainable production levels. There is a need for increased UHDP system and drip system in present date for effective utilisation of land and resources by which farmers can take more benefits from their land.

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