Crimson Publishers
Wings to the Research

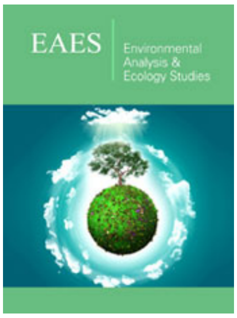
Research Article

Automated Butterfly Valve Controlled with Smartphone for Soil Management in Mango Orchards

Federico F Hahn*, Hugo Roblero Ley and Martin Hidalgo

Department of Agricultural Engineering and Water Use, Mexico

ISSN: 2578-0336



***1Corresponding author:** Federico Hahn, Department of Agricultural Engineering, Mexico

Submission: January 28, 2019
Published: April 03, 2019

Volume 5 - Issue 3

How to cite this article: Federico F H, Hugo Roblero L, Martin H. Automated Butterfly Valve Controlled with Smartphone for Soil Management in Mango Orchards. Environ Anal Eco stud. 5(3). EAES.000612.2019.
DOI: 10.31031/EAES.2019.05.000612

Copyright@ Federico Hahn, This article is distributed under the terms of the Creative Commons Attribution 4.0 International License, which permits unrestricted use and redistribution provided that the original author and source are credited.

Abstract

In the last decade, climate changes decreased precipitation and increased soil temperature. Global warming increased fire frequency and severity in orchards bushfires. Mangoes are trees that drop leaves once they have dried creating an ideal environment for rapid soil fire spreading. As wildfire eradication schemes at farm level are a priority in our country, a sprinkler irrigation system was installed in an experimental orchard. Water management produced more fruit and established grass within the trees canopy. Automated valves were designed to water the orchard by using buried PVC pipes. The motorized butterfly valve was opened by a starting pulse letting the water flow and was closed after receiving another pulse when the irrigation period was over. Several valves worked together to provide the water required for one hectare being the energy provided by a lithium ion battery charged with a micro turbine. Optimum energy management during valve opening and closure can only be performed under minimum friction. Wireless transmission turns off the pump to optimize this process. The sprinkler irrigation kept moisture within the soil providing a wildfire protection system.

Keywords: Mango orchard; Wildfire eradication; Motorized butterfly valve; Smartphone application; Wireless transmission

Introduction

In recent decades, the climate has been observed to change and these changes have led to shifts in precipitation regimes and to temperatures fluctuations [1]. Changes in micro and macro climates lead to droughts and floods, and to changes in seasonal weather patterns [2]. These are affecting agricultural systems and livelihoods in several regions around the world where poverty is widespread [3-5]. From the experience of banana farmers, banana grows at temperatures between 10 and 40 °C. Above 40 °C, the crop needs more irrigation, leaves dry and trees fruit less having a direct impact on productivity [6]. Farmers have realized that oranges flower and ripen earlier, which has a negative impact on productivity and taste [7]. Farmers used to rely on traditional forecasting, by observing how nature behaves on local trees, insects and movement of winds. For example, if the mango tree produces many fruits, it means that there is going to be drought that same year [8]. Improved technologies for tree plantation development, and reforestation, together with improvement of protection from fires, insects and diseases should be implemented [9]. Global warming is likely to increase fire frequency and severity [10,11].

The number of days above 35 °C is expected to increase by 20% in Western Australia by 2030 showing rainfall decline, intense droughts, and bush fires [12]. The maximum daily Forest Fire Danger Index (FFDI) and Grassland Fire Danger Index (GFDI) are used to monitor fire risk, schedule prescribed burning and declare Total Fire Ban days [13]. Soil moisture, drought and fire danger indicators for present conditions are derived daily for fire risk assessments [13]. Establishment of wildfire eradication schemes at national/farm levels are required to reduce farming communities' disasters [11]. In circumstances where agricultural burning is absolutely necessary, best burning management practices should be followed [14]. The burn heat in pasture lands and orchards depends on the amount of dry pasture plant material and wind speed. Where plant material is sparse, cool to moderate burns occur. Pasture recovery after a bush fire is affected, to a major degree, by the heat of the fire [15]. Bushfires result in heavy smoke damage and growers suffer million losses from fires in adjoining national parks [13].

Mango trees have a very well spread, deep, and extensive root system. The young and non-bearing orchards require light and frequent irrigation to boost fast and vigorous growth of plants and are usually irrigated at weekly interval, meanwhile the bearing orchards are irrigated at regular intervals from 10 to 15 days [16]. Proper water management require of modern systems such as drip [16-19], bubbler [19-21] and sprinkler [22-25] irrigation methods. These systems are considered the most important practical and efficient for mango irrigation water application compared to traditional irrigation practices.

Mango orchards are prone to drop dry leaves providing excellent dry matter as soil and tree nutrient if properly managed. If the soil is very dry, the dry matter will not disintegrate becoming an excellent material to start a bush fire. This research was done to create an automated sprinkler system to irrigate one hundred mango trees planted in one hectare. The watering periods are programmed with a smartphone and a microcontroller acts as a timer to turn-on and off energy efficient motorized butterfly valves. The grass growing beneath the trees eradicates any bush fire possibility.

Materials and Methods

Experimental plantation and sprinkler installation

The study was conducted at the Loma Bonita, Guerrero, Mexico (17°28'48"N, 101°11'19"W) from February to July 2018. In the mango orchard there are 605 mango trees: 355 of varieties Kent and 255 of variety Haden grown on clay loam soil that was analyzed before and after irrigation. Trees had canopy radius between 4 to 5.5m and each tree was irrigated by four drippers (Figure 1a) installed at a distance of about 0.5 to 0.6m from the trunk. Moisture was observed within a radius of 2-3m and decreased towards the outer sides of the tree canopy. Eighteen small rotating mini sprinkler spray water kits (ISS576) were added per hectare [24], having each an area coverage of 576m^2. Each kit has four laterals spaced 6m and with 4 sprinklers each (Figure 1a). Distance between kits is of 6m so that all the surface is watered.

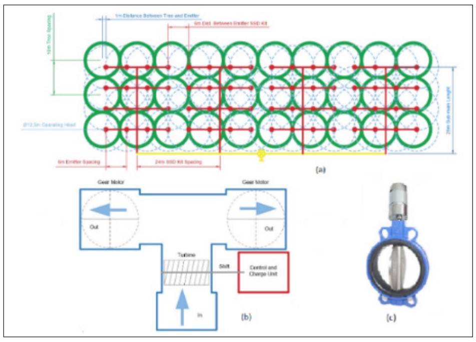


Figure 1: One third-hectare orchard diagram with

(a) Irrigation kits,

(b) Valve block diagram and with lateral valve output view.

The irrigation system used a Grundfos SPA10 pump powered by a 1.5kW motor and discharging 2 liters per second [26]. As the orchard is on a hilly mound, the flow required by kit was of 300lph so all the kits could irrigate simultaneously. One and a half hour of sprinkling provides the 112 liters that each 20-year old tree requires for 115% of crop water requirement [24]. In order to protect the pump, half of the water was applied daily from 7:00 to 8:30am and the rest from 9:00 to 10:30am. This operation was used to test the operation of the butterfly valve.

Valve design and operation

A 2.54cm diameter butterfly valve (Figure 1b) was coupled to a 3.2cm long gear motor (model GM25-375, Jiechuangsen Technology Co., Ltd., China). The gear motor provided a speed and torque of 24 RPM and 10kg cm, respectively. Ten 6-volt pulses of 150 milliseconds were supplied from a lithium-ion pack consisting of two ICR18650 battery through a MOSFET transistor (IRF540, Vishay, India) using a load current of 90mA. The 7.4V battery pack provided 2200mAh, so the valve opened and closed 12 times. Each of the two valves are connected at one end of the T connection and a plastic turbine is placed at the entrance (Figure 1b). The turbine that is an inverted fan has 7 blades and rotates freely when the pumped water circulates through the pipeline; a voltage of 9V is produced when the water flows at 2lps. This voltage is connected through a charger to the battery pack and will maintain it ready for use. A smartphone programs the NANO Arduino microcontroller using a Bluetooth connector if the sprinkling periods have to be modified.

Programming

Every day each valve is turned-on once and it is closed after the sprinkler watering period of 90 minutes is over (Figure 2). The routine carried out by the microcontroller starts by stopping the pump and turning by 90° the first valve so that it lets the water flow. In this moment, valve-2 should be closed. The pump is started through a wireless system that activates remotely the starting solenoid relay and remains working for 90 minutes. Once the pump stops, valve-1 closes and valve-2 turns-on (Figure 2). The system is ready to sprinkle again, and the pump is started remotely for 90 minutes.

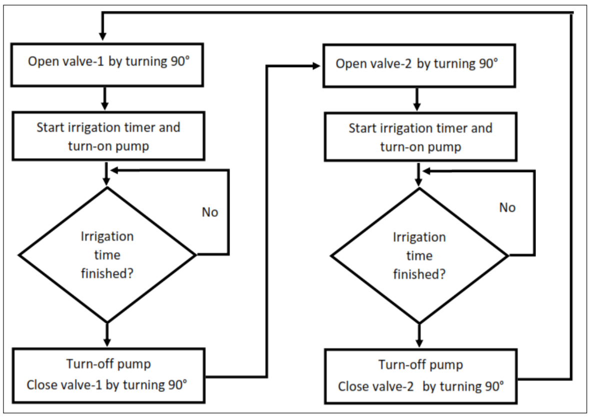


Figure 2: Flow diagram of sprinkler control with two valves.

Copyright © : Federico Hahn

Result and Discussion

A warming climate could well increase growth rates, pollen viability and fruit set in mango orchards [12]. However, temperatures above 45 °C will affect fruit development, particularly induction, size and number of flowers. Growing areas will experience risks of abnormal flowering and may cause poor fruit to set with reduced quality and yield [27].

It is necessary to compare the different water management techniques. Drip irrigation systems does not cover the entire canopy hence plant remains stressed [16]. Plant growth of mango trees irrigated without controlled watering methods was similar to, but signs of leaf wilting stress were observed under drip irrigated trees [16]. Micro-sprinkling irrigation [18] has the advantage that it can effectively reduce water consumption, increase yields and agronomic water use efficiency. Growers using drip irrigation are changing to micro-sprinkler due to ease of field management and reduced need for water filtration and treatment when using sprinklers [23]. The results of our experience shows the vulnerability of the orchard under scarce irrigation (Figure 3a) as soil becomes very dry but after sprinkler irrigation (Figure 3b) the soil becomes moist. The valve designed operated well and the current required to open it with water circulating was of 170mA which was reduced to 120mA without hydraulic charge. It was further reduced with the pulsed power supply applied to the gear motor. With the turbine working daily, the battery was always charged.

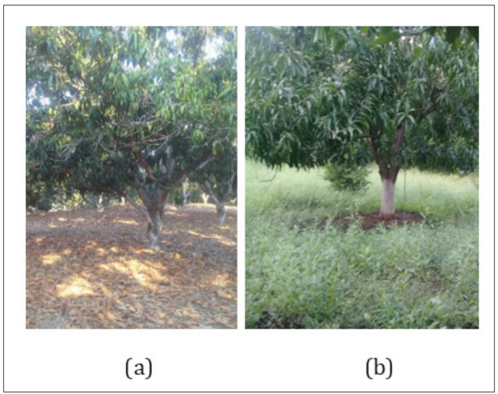


Figure 3: Mango trees under
(a) Null watering and
(b) Sprinkle irrigation.

The effects of orchard floor management systems on weed management, soil conditions, tree growth, tree yield, fruit quality, and fruit storage potential are important [28]. Living mulch systems increases soil respiration, decreased tree vigor, and improved fruit quality but decreases fruit yield [29]. It is important to introduce all the organic matter in the form of a sandwich using a mower for proper orchard floor management [28]. Soil physical properties appeared due to cultural practices and mode of irrigation. The average dry bulk density was 1.37gcm^{-3} of pure soil and of 1.27gcm^{-3} after one year of sprinkle irrigation. These results are very close to the ones obtained under basin and bubbler irrigation [19].

Conclusion

The sprinkler system used as floor management worked well as a wildfire eradication schemes in mango orchards. The automated valve was programmed via smartphone and a 1.5HP water pump could be used for 4 hectares. The lithium batteries charged by the turbine allows to have the necessary energy to open and close the automated valves. Current saving was approached by using valves without friction.

References

1. International Panel on Climate Change (IPCC) (2014) Climate Change: Synthesis Report; Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; IPCC, Geneva, Switzerland.
2. Singh D, Tsiang M, Rajaratnam B, Diffenbaugh NS (2014) Observed changes in extreme wet and dry spells during the South Asian summer monsoon season. Nat Clim Chang 4: 456-461.
3. Pokhrel DM, Pandey B (2011) Climate change adaptation: strategic vision in agriculture. J Agric Environ 12: 104-112.
4. Karki R, Gurung A (2012) An overview of climate change and its impact on agriculture: A review from least developing country. Nepal Int J Ecosyst 2: 19-24.
5. Niles M, Ahuja R, Esquivel J, Mango N, Duncan M, et al. (2017) Climate change & food systems: Assessing impacts and opportunities. Meridian Institute.
6. Ranjitkar S, Sujakhu N, Budhamagar K, Rimal S, Xu J et al. (2015) projected climate change impacts on climatic suitability and geographical distribution of banana and coffee plantations in Nepal; World Agroforestry Center (ICRAF): Nairobi, Kenya.
7. Barrueto AK, Merz J, Kohler T, Hammer T (2018) What prompts agricultural innovation in rural Nepal: A study using the example of macadamia and walnut trees as novel cash crops. Sustainability, In press 8(2): 21.
8. Mubaya CP, Njuki J, Liwenga E, Mutsvangwa EP, Mugabe FT (2010) Perceived impacts of climate related parameters on smallholder farmers in Zambia and Zimbabwe. Journal of Sustainable Development in Africa, Clarion University of Pennsylvania, Clarion, Pennsylvania. 12(5): 170-186.
9. Lasco RD, Pulhin FB, Sanchez PAJ, Villamor GB, Villegas KA (2008) Climate change and forest ecosystems in the philippines: vulnerability, adaptation and mitigation. Journal of Environmental Science and Management 11(1): 1-14.
10. Brown TJ, Hall BL, Westerling AL (2004) The impacts of 21st century climate change on wildland fire danger in the western United States: an application perspective. Climatic Change 62(1-3): 365-388.
11. ECLAC (2011) The economics of climate change in the Caribbean Summary Report 2011. United Nations Economic Commission for Latin America and the Caribbean. Trinidad and Tobago, Port, Spain.
12. Barlow S, Cullen B, Darbyshire R, Day R, Eckard R, et al (2015) Appetite for change global warming impacts on food and farming regions in Australia. Melbourne Sustainable Society Institute. Australia.
13. Hennessy K, Lucas C, Neville N, Bathols J, Suppiah R, et al. (2005) climate change impacts on fire-weather in south-east Australia. CSIRO Marine and Atmospheric Research, Australia.
14. Ministry Agriculture (2014) Farm practice burning. Order No. 870.218-28. British Columbia Ministry Agriculture, Columbia, USA.
15. Freebairn R (2017) Pasture recovery after bushfires. Primefact 539, second edition, Department of Primary Industries, State of New South Wales, Australia. ISSN 1832 6668.

Copyright © : Federico Hahn

16. Mirjat MS, Jiskani MM, Siyal AA, Mirjat MU (2011) Mango production and fruit quality under properly managed drip irrigation system. Pak J Agri 27(1): 1-12.

17. Mattar MA (2007) Irrigation systems effect on growth and productivity in mango orchard. Misr J Ag Eng 24(1): 103-121.

18. Spreer W, Ongprasert S, Hegele M, Wünsche JN, Müller J (2009) Yield and fruit development in mango (Mangifera indica L. cv. Chok Anan) under different irrigation regimes. Agricultural Water Management 96(4): 574-584.

19. Soothar RK, Chandio S, Mangrio M, Mirjat M, Talpur MA (2015) Comparison of bubbler and basin irrigation methods in a Bivarietal Mangifera Indica orchard in Pakistan. Science International, ISSN 1013-5316 27(2): 1229-1236.

20. Soothar RK, Mirjat MS, Rehman H, Velo S, Memon S, et al. (2016) Evaluation of bubbler irrigation system at different emission flow rates for young mango orchard. American Journal of Engineering Research 5(8): 35-42.

21. Behoteguy D, Thornton JR (1980) Operation and installation of a bubbler irrigation system. ASAE. Paper No. 60-2059. p: 16.

22. Wei J, Liu G, Liu D, Chen Y (2017) Influence of irrigation during the growth stage on yield and quality in mango (Mangifera indica L). PLoS ONE 12(4): e0174498.

23. Lu P (2005) Mango water relations and irrigation scheduling. In: Malik (Ed.), Proceedings of International Conference on Mango and Date Palm: Culture and export, University of Agriculture, Faisalabad, Pakistan, pp. 20-23.

24. Heryani N, Kartiwa B, Apriyana Y, Syahbuddin H (2016) Production and quality enhancement of mango using fan jet sprayer irrigation technique. Indonesian Journal of Agricultural Science 17(2): 41-48.

25. Teixeira AH, Bastiaanssen WGM (2012) Five Methods to Interpret Field Measurements of Energy Fluxes over a Micro-Sprinkler-Irrigated Mango Orchard. Irrigation Science 30(1): 13-28.

26. IDE (2007) Horticulture easy drip kit. Technical manual for IDEal micro irrigation systems. IDE International Development Enterprises. USA.

27. Rajan S (2012) Phenological responses to temperature and rainfall: a case study of mango. In Tropical Fruit Tree Species and Climate Change, edited by B.R. Sthapit, V. Ramantha Rao and S. R. Sthapit, 7196. Biodiversity, New Delhi, India.

28. Tahir II, Svensson SE, Hanson D (2015) Floor management systems in an organic apple orchard affect fruit quality and storage life. Hort Science 50(3):434-441.

29. Atucha A, Merwin IA, Brown MG, Gardiazabal F, Mena F, et al. (2013) Root distribution and demography in an avocado (Persea Americana) orchard under groundcover management systems. Funct Plant Biol 40(5): 507-515.

For possible submissions Click below:

Submit Article

Copyright © : Federico Hahn