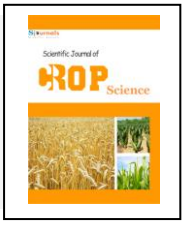
Sjournals
Scientific Journal of Crop Science (2012) 1(5) 76-82
ISSN 2322-1690

Contents lists available at Sjournals
Scientific Journal of CROP Science
Journal homepage: www.Sjournals.com



Original article

Effect of pulse irrigation scheduling with hybrid station controller on fruit yield and quality of nagpur mandarin (*citrus reticulate* blanco)

P.S. Shirgure
National Research Centre for Citrus, Nagpur (M. S.), India.

*Corresponding author; National Research Centre for Citrus, Nagpur (M. S.), India.

ARTICLE INFO

Article history:
Received 08 December 2012
Accepted 25 December 2012
Available online 30 December 2012

Keywords:
Automatic pulse irrigation scheduling,
Citrus,Drip irrigation
Micro-irrigation
Nagpur mandarin
Hybrid station controller
Fruit yield and quality

ABSTRACT

The hybrid station controller based automatic pulse irrigation scheduling field experiment was conducted on 10-12 years old bearing Nagpur mandarin (*Citrus reticulata* **Blanco**) at National Research Center for Citrus, Nagpur during 2008-2011. The objective was to study the automatic daily irrigation scheduling as well as alternate day based on time schedule and potential evapo-transpiration through the drip irrigation. The treatments were consisted of Automatic daily irrigation daily with 60 minute interval three times (I_1); Automatic irrigation daily with 90 minute interval two times (I_2); Automatic irrigation at alternate day with 120 minute three times (I_3); and Automatic irrigation at alternate day with 180 minute two times (I_4) with six replications in Randomized Block Design. The automatic hybrid station controller E-6 (Rain Bird, USA) was used for micro-irrigation schedule setting the time for each treatment based on the water need of the plant and average open pan evaporation. The various scheduling treatment timings were programmed in A, B and C programs of the hybrid station controller. The sustainable production of Nagpur mandarin is possible with drip irrigation using automatic scheduling daily or on alternate days. The water use in October varied from 65.0-72.4 liters/day/plant and during May-June it was 133.0 - 147.7 liters/day/plant. Drip irrigation

was scheduled to maintain automatically the soil moisture status above 25% (wet basis) during fruit growing period. The leaf nutrient status was high with automatic alternate day drip irrigation schedule. The canopy temperature was positively influenced with automatic drip irrigation schedules. The Nagpur mandarin fruit yield was highest (30.91 tones/ha) with irrigation on alternate day 120 minutes three times, followed by irrigation scheduled with 90 minutes interval two times daily (30.11 tones/ha). Fruit weight (154.7 g), TSS (10.22 ^{0}Brix) and juice percent (40.77%) was found with automatic irrigation at alternate day with 120 minute three times. The automatic drip irrigation scheduling can be better substitute for manual drip irrigation operation and enhancing the water use efficiency.

1. Introduction

Nagpur mandarin (*Citrus reticulata* Blanco) is an important citrus crop grown in 1.48 lakh ha area (bearing area is 86,200 ha) with production of 8.75 lakh tonnes. The average productivity is 10-11 tonnes/ha, which too low as compared to other citrus cultivars. This is due to water stress, improper and calendar method of scheduling, the gravity irrigation method, lack of micro-irrigation systems and inadequate soil moisture during the critical plant growth and fruit developmental stages. Due to increasing scarcity of water, the conventional irrigation methods are being replaced with drip irrigation systems in Nagpur mandarin orchards. But the drip system is not operated regularly maintaining the correct irrigation intervals with manual operation the irrigation interval uniformly is not maintained properly. The mandarin yields can be increased from 10 to 15 tonnes/ha with adoption of the drip system and manual system operation. For further increasing the productivity automation of the existing drip irrigation systems is highly essential. The production and productivity potential of the Nagpur mandarin can be enhanced with the adoption of the modern drip irrigation systems under tree micro-jet irrigation systems (Shirgure *et al.,* 2003) and quality fruits with micro-irrigation and fertigation technology (Shirgure *et al.,* 2001) and automation (Shirgure *et al.,* 2000; Shirgure *et al.,* 2004).

A compurterized approach to irrigation timings allows growers to know when critical moisture levels are expected to occur. The computer enables rapid analysis of a number of variables and the system used in simple, reliable and accurate. Grower inputs are minimal namely monitoring rainfall and irrigation levels and determining the soil moisture depletion level for the grove. Citrus growers are provided with a projected data when tree stress will start, but decide when to start irrigation (Jackson and Ferguson, 1981). The computer based feed back system in citrus groves. Information on soil moisture and fertilized levels is registered by sensors and fed into a micro-computer, which initials, controls and terminates irrigation or fertigation (Bolden *et al.,* 1985). Eight to ten year old trees cv. *Valancia* on citrus *aurantium* rootstock planted at 8 x 4 m in red loamy soil in Cuba were irrigated at 65,75, 85 or the conventional 80% of field moisture capacity or they were not irrigated. The highest yield was produced by irrigation at 85% moisture capacity and improved fruit quality also (Peres, 1987). Cavazza (1991) assessed the value of automatic irrigation systems in reducing labour and water consumption costs three levels of automation were considered Local automation control, Cyclic automation and Central programming automation. A simplified irrigation schedule for citrus growers in the Mediterranean was developed on a citrus farm in Sicily, Italy. The automation system could be implemented using a meteorological, station, a personal computer, field units and electrodes. Daily gross requirements were calculated from the net requirement and application efficiency. Reference ET was calculated as the emerge between the value obtained by applying the formula of *Hargreaves-Samani* and the readings obtained in a class A evaporation pan (Sardo, 1992). A survey of the Florida citrus industry conducted that larger operations continue to be more likely to use a computer than smaller

operations if there using computers the largest citrus operations are also more likely to use more specialized software applications for production automations citrus production decision aids, and accessing weather information (Ferguson and Israel, 1998). The existing drip system in Nagpur mandarin orchard was converted to automatic drip irrigation system using ESP-4 Hybrid Station Controller, 100 PGA Solenoid Valve. The soil moisture content at 30 cm depth in the root-zone was ranged from 27.2 - 29.8 % which is 10-15 % below the field capacity. The growth of the mandarin enhanced from 65.2 to 81.4 m^3 due to drip modernization. Fruit yield also increased from 17.6 to 25.1 tonnes/ha. The fruit quality is also improved due to the automatic controller based drip irrigation system. The optimum quantity of water required for the bearing Nagpur mandarin plants varied from minimum 47 to 70 litres per day per plant during October - December and maximum 118 to 129 litres per day per plant during April -June. The study indicated that the automatic drip irrigation scheduling using controller have potential for water saving and sustaining the Nagpur mandarin yield and quality (Shirgure *et al.,* 2005; Shirgure and Srivastava, 2012). Pulse irrigation images shown in Fig. 1.

The objective was to investigate the conversion of the existing drip irrigation system in Nagpur mandarin orchard to automatic drip irrigation scheduling system using ESP-6 Hybrid Station Controller with drip irrigation system. The pumping is automatically as per the program scheduled into the controller so as to maintain uniform and continuous soil moisture in root zone, besides increasing the yield and quality of Nagpur mandarin fruits.

2. Materials and methods

The automatic irrigation scheduling experiment was conducted in the block of 0.25 ha with 6 spacing at experimental farm of NRCC during 2008-2011. The objective was to study the automatic irrigation scheduling daily as well as alternate day based on time schedule as per the treatments and considering potential evapo-transpiration through the drip irrigation and the effect on growth, yield and quality of 12-14 years old bearing Nagpur mandarin. The treatments were Automatic irrigation daily with 60 min interval three times (I_1), Automatic irrigation daily with 90 min interval two times (I_2), Automatic irrigation at alternate day with 120 min three times (I_3) and Automatic irrigation at alternate day with 180 min two times (I_4) with six replications in Randomized Block Design. The texture of the soil was clay loam and depth of the soil is 41 cm. The composite soil samples were collected for determination of field capacity and permanent wilting point. The FC and PWP of the field under study was 30.44% and 19.56% respectively. The available water content of the soil was 10.89 %. The bulk density of the soil in field was determined using core sampler having 100 cm^3 volume and oven drying. The bulk density of the field was 1.34 g/cc. The water holding capacity of the soil was 14.59 cm/m depth of soil. The Extra Simple Programming (ESP) with self display made the electronic controller easy to program, read and work. The Hybrid station controller and solenoid valves were installed in the field for use. The easy programmable hybrid station controller (4-6 stations) automatically operates the electronic solenoid vale for the specified programmed duration. It has 3 program (A, B and C) independently having 6 start times and 4 control stations. Each station runs for 4 hours at the most. It has a feature of frequency of irrigation setting also. The water budgeting is also possible fro 10 to 200 % of the time set. The Hybrid Station Controller (E-6, Rain Bird, USA) and Solenoid valve (Hunter, USA) are installed in field.

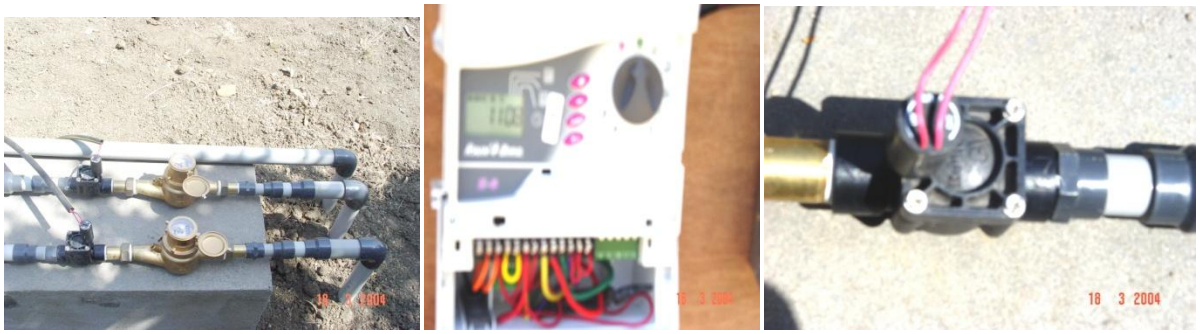


Fig. 1. Pulse irrigation images.

The electrical control panel consisting of power supply, main switch, pump control relays and hybrid station controller was installed in the experimental field. The ground station consisting of valves and water meters is also installed for operating as per the controller settings and defined treatments. The irrigations are followed based on open pan evaporation and by setting the time for each treatment based on the water need of the plant in every month. The drip irrigation system consisting of 16 mm dia. lateral and 8 liters per hour drippers (4/plant) was installed in the field along with the other accessories. The plant growth parameters were recorded during October 2008. Increase in vegetative growth parameters, i. e plant height, girth and canopy volume, were recorded in October 2009 -10. The stock girth was taken 15 cm and scion girth at 25 cm above the soil surface. The canopy volume of the mandarin tree was calculated using spread and canopy height using Castle's formula. The total fruits harvested from each tree were weighed for computing the yield. The total soluble solid was determined using hand refractometer (0-32 ^{o} Brix). Titratable acidity was determined by titrating the juice against 0.1N NaOH. Percent juice content was determined by extracting the fresh juice and weighing. The data was analysed with standard procedure.

3. Results and discussion

3.1. Irrigation scheduling and water use with automation

The controlled irrigations are given based on open pan evaporation and by setting the time for each treatment based on the water need of the plant in every month. The total quantity of irrigation water scheduled on daily as well as on alternate day basis is nearly same and according to the treatments and program given in controller. The daily maximum open pan evaporation ranged from minimum 3.4 mm per day in December to maximum 12.7 mm per day in May. Water quantity of the plant on daily basis during March 2009 to February 2011 was measured by water meters, which are installed in the experimental plots. The minimum quantity of water given to the mandarin plants was 46.9 to 55.4 litres per day per plant during November – December, 2009 and it was maximum i.e.118.4 to 129.1 litres per day perplant during May 2011. The quantity of water scheduled using automatic drip irrigation and various duration daily and alternate day basis to the Nagpur mandarin plants was minimum (65.00 to 72.4 litres per day per plant) during October month and maximum (133.04 to 147.7 litres/day/plant) during May, 2010. There was no much variation on monthly quantity of water applied to the mandarin plants. The *in situ* soil moisture was monitored using moisture probe during the summer months from March to June. The observations were taken from 1st March, 2009 to 22nd June during both the year 2009 and 2010. The volumetric soil moisture at 15, 30, 45 and 60 cm depth was measured at the interval of 4-5 days. The soil moisture was monitored at higher level (above 25 % wet basis) in the automatic irrigation scheduled daily with 90 minute two times and automatic irrigation scheduled at alternate with 180 minute two times. The soil moisture was maintained between 15-25 % in automatic irrigation scheduled daily with 60 minute three times and irrigation scheduled alternate day with 120 minute three times. From the data it is clear that the automatic irrigation schedules affected the soil moisture and it was higher during the critical summer months from March to June. This clearly indicates that soil moisture was maintained higher in automatic irrigation scheduled automatic irrigation daily with 90 minute interval two times and automatic irrigation daily with 180 minute interval two times, which have higher and continuous flow rates. The fluctuations over the period are also not observed. Iit is also clear that the automatic irrigation schedule having 90 minutes two times daily and 180 minutes two times alternate days maintains higher soil moisture during the year 2009. The soil moisture was maintained higher uniform in automatic irrigation scheduled automatic irrigation daily with 90 minute interval two times and automatic irrigation at alternate day with 180 minute two times, which have higher and continuous flow rates during the year 2010.

3.2 Growth of mandarin plants

The effect of different automatic irrigation scheduling on daily as well as on alternate basis has influenced on the growth of Nagpur mandarin. The growth of mandarin plant recorded during October month of the year 2008-10. Data of plant height, plant spread have been used in estimating the canopy volume. The plant height and stock girth is not significant. The average height of the Nagpur mandarin plant ranged from 5.10 -5.42 m, stock girth from 71.75 -76.03 cm. The significant difference was also observed in canopy volume also, ranging from 64.56 -87.81 m^3 (Table 1). The average plant and stock girth was higher in automatic irrigation at alternate day with 120 minute three times followed by automatic irrigation daily with 90 minute interval two times. The canopy volume is

significantly affected due the automatic micro-irrigated schedules. The average canopy volume observed was higher (87.81 m^3) in automatic irrigation scheduled alternate day with 120 minute interval three times followed by automatic irrigation scheduled daily with 180 minute interval two times (84.83 m^3) as compared to the treatment automatic irrigation scheduled at daily 60 minute interval three times (66.6 m^3) and automatic irrigation scheduled daily with 90 minute interval two times (64.56 m^3) during the year 2008-11. This is mainly due to availability of constant and continuous soil moisture in plant root zone. The similar observations were also recorded in the studies on Nagpur mandarin (Shirgure *et al.,* 2000).

3.3 Mandarin fruit yield and quality

The automatic controller based drip irrigation scheduled on daily and alternate day having1-3 hour's duration and two to three pulse a day has profound effect on the yield and fruit quality of the Nagpur mandarin during 2008-11. The Nagpur mandarin fruits were harvested during first fortnight of November the samples were randomly selected for determining the fruit quality. Yield and quality were significantly influenced by the different automatic irrigation schedules (Table 2). The fruits per plant, fruit yield and TSS was found significant during 2004 - 05. The juice percent was also found significant in harvesting season of 2005. The average fruit weight and acidity were not significant may due the internal fruit quality as well as the effect of drip irrigation was uniform on all plants. So, significant difference was not observed on the average weight of the fruits. The average number of fruits per plant, yield, TSS, Juice content, acidity and TSS to acidity ratio was analysed for the study period and pooled data in presented in Table 2.

Table 1
Growth of Nagpur mandarin under different irrigation schedules during October 2008-10.

Treatments	Plant height (m)				Stock girth (cm)				Canopy volume (m^3)			
	2008	**2009**	**2010**	**Mean**	**2008**	**2009**	**2010**	**Mean**	**2008**	**2009**	**2010**	**Mean**
I_1	4.96	5.11	5.23	5.10	67.42	72.92	74.90	71.75	61.94	67.99	69.87	66.60
I_2	5.11	5.22	5.27	5.20	69.5	76.25	78.25	74.67	56.18	67.11	70.38	64.56
I_3	5.26	5.45	5.54	5.42	72.75	76.33	79.00	76.03	81.43	89.64	92.37	87.81
I_4	5.27	5.29	5.45	5.34	72.75	77.13	78.20	76.03	78.99	86.87	88.62	84.83
LSD *(P = 0.05)*	NS	NS	NS	NS	NS	NS	NS	NS	13.61			1.34

I_1 - Automatic irrigation daily with 60 minute interval three times, I_2 - Automatic irrigation daily with 90 minute interval two times, I_3 - Automatic irrigation at alternate day with 120 minute three times and I_4 - Automatic irrigation at alternate day with 180 minute two times

Table 2
The average fruit yield and quality of the Nagpur mandarin during 2008-2011 (pooled data for 3 years).

Treatment*	Number of fruits / plant	Yield (tonnes / ha)	TSS (^{0}Brix)	Average weight of fruit (g)	Juice (%)	Acidity (%)	TSS / acidity ratio
I_1	606	24.50	9.71	146.54	38.64	0.83	11.7
I_2	747	30.11	9.49	151.96	37.68	0.81	11.7
I_3	726	30.91	10.22	153.67	40.77	0.78	13.2
I_4	638	27.04	9.92	152.23	37.93	0.80	12.4
CD *(P = 0.05)*	29	0.54	0.37	0.81	1.21	0.04	0.72

* The treatments are as given in Table 1 above.

All the yield as well as fruit quality data was significant with respect to the differential automatic drip irrigation schedules. The average number of fruits per plant varied from 606 to 726 in different automatic drip irrigation schedules. The number of fruits per plants was highest in the automatic irrigation at alternate day with 120 minute three times followed by automatic irrigation daily with 90 minute interval two times. The various drip irrigation scheduling significantly influenced the yield of the Nagpur mandarin. It increased the yield from 24.5 to 30.91 tonnes/ha. The highest mandarin fruit yield was recorded in the automatic drip irrigation at alternate day with 120 minute three times i.e. 30.91 tonnes/ha (Table 2). The moderate yield was observed in automatic drip irrigation daily with 90 minute interval two times (30.11 tonnes/ha) followed by automatic drip irrigation daily with 180 minute interval two times (27.04 tonnes/ha). The lowest fruit yield was seen in irrigation scheduled daily having 60 minutes and three times. This clearly indicated that the automatic drip irrigation schedules on daily and alternate days maintained higher as well as continuous soil moisture influenced by the water and nutrient uptake resulting into good quality fruits besides enhancing the yield. The mandarin fruit diameter ranged from 1.51 to 6.87 cm during the study period. High fruit growth rate was seen in automatic irrigation at alternate day with 180 minute two times in 2009 and 2010. The highest average fruit weight (153.67 g.) and lowest acidity (0.78) is observed in the automatic drip irrigation at alternate day with 120 minute three times. The TSS (10.22 ^{o}Brix) and juice percent (40.77 %) was more in the automatic drip irrigation at alternate day with 120 minute three times (Table 2). The TSS/acidity is indicator of sweetness of the fruit of *Ambia* flush during October-November month. If the TSS to acidity ratio is high means that the fruits have more TSS (total soluble solids) and less acidity. This ratio was analysed for all the treatments. The highest TSS/acidity was found in the automatic drip irrigation at alternate day with 120 minute three times (13.2) followed by automatic drip irrigation at alternate day with 180 minute two times (12.4). The lowest TSS/acidity (11.7) was observed in automatic drip irrigation with 60 minute three times daily.

4. Conclusion

The sustainable and higher production of Nagpur mandarin is possible with automatic drip irrigation using automatic scheduling daily or on alternate days which maintained the higher water application to the mandarin plants. Drip with automation maintained the soil moisture status above 25 % (wet basis) through out the fruit growing period. The Nagpur mandarin yield was highest with irrigation on alternate day 120 minutes three times. Highest fruit weight, TSS, juice percent and TSS/acidity ratio was found with automatic irrigation at alternate day with 120 minute three times. The automatic drip irrigation scheduling could be better substitute for manual drip irrigation operation and enhancing the water yield fruit quality, water and fertilizer use efficiency.

References

Bolden, J.L., Fay, K.B., Miller, R.N., 1985. Computer based feed back system for the care and management of citrus groves. Proc. of American Society of Agriculture Engineering conference held at Chicago during 25-28th February, 1985, P-90-95.

Cavazza, D., 1991. Farm automation of irrigation systems in open – field greenhouse crops. Irrigazione et al. Drenaggio, **38** (4), 21-6.

Ferguson, J.J., Israel, G.D., 1998. Computer use by Florida citrus growers. Proc. of Seventh International Conference on Computers in Agriculture, Orlando, Florida, during 26-30th October 1998.

Jackson, J.L., Ferguson, F.J., 1981. Computerized irrigation scheduling. Proc. Of the Florida State Hort. Sci. **93,** 5-6.

Marsh, A.W., 1968. Automatic tensiometer signaled irrigation systems for orchards. California citrograph, **54**, 2-12

Peres, E.M.T., 1987. Effort of irrigation on the yield and quality of orange fruits. Rosteniev dni Nauki, **24** (2), 71-76.

Sardo, V., 1992. Simplified automatic management of irrigation. Proc. of Seventh International citrus Congress, Acireale, Italy, 8-13, March 1992.

Shirgure, P.S., Srivastava, A.K., Shyam, S., 2000. Automatic drip irrigation system in Nagpur mandarin. Abstract IXth International Society of Citriculture Congress held at Florida (USA) on 3-7 December, 2000, p-141.

Shirgure, P.S., Srivastava, A.K., Shyam, S., 2001. Growth, yield and quality of Nagpur mandarin (Citrus reticulata Blanco) in relation to irrigation and fertigation. Indian J. Agri. Sci., **71** (8), 547-50

Shirgure, P.S., Srivastava, A.K., Shyam, S., 2003. Evaluating micro-irrigation systems in Nagpur mandarin under sub-humid tropical climate. Trop. Agri. (Trinidad), **80** (2), 91-6.

Shirgure, P.S., Srivastava, A.K., Shyam, S., 2004. Automation of drip irrigation system improved yield and quality of Nagpur mandarin (Citrus reticulata Blanco). Paper presented in First Indian Horticultural Congress 2004 at IARI, New Delhi held during 6-9th November, 2004. p- 205.

Shirgure, P.S., Srivastava, A.K., Shyam, S., Panchariya, G.S., 2005. Yield and quality of Nagpur mandarin under different automatic drip irrigation schedules. Paper presented in the International Conference on Plasticulture and Precision Farming at Hotel Ahoka, New Delhi during 17^{th} –21^{st} November, 2005. p-228.

Shirgure, P.S., Srivastava, A.K., 2012. Automatic pulse irrigation scheduling for enhancing the productivity and quality of drip irrigated Nagpur mandarin (Citrus reticulata Blanco). Paper presented in 5th Indian Horticultural Congress 2012 at PAU, Ludhiana held during 6-9th November, 2012. P-283.