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Short communication

Effect of automatic micro-irrigation scheduling on productivity and quality of Nagpur mandarin

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ABSTRACT

An experiment was conducted on 12-14 year-old bearing Nagpur mandarin (*Citrus reticulata* Blanco) trees to study the automatic daily irrigation scheduling as well as alternate day based on time schedule through the drip irrigation during 2007-2010. The treatments were consisted of automatic daily 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 sustainable quality fruit 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 l/ day/ plant and during May-June it was 133.0 - 147.7 l/ day/ plant. The fruit yield was 30.91 tonnes/ ha with irrigation on alternate day 120 min. three times, followed by irrigation scheduled with 90 min. interval two times daily (30.11 tonnes/ ha). Fruit weight (154.7 g), TSS (10.22°Brix) and juice percent (40.77) was found higher with automatic irrigation at alternate day with 120 min. three times. The automatic drip irrigation scheduling was found as better substitute for manual drip irrigation operation besides enhancing the yield, fruit quality and water use efficiency in Nagpur mandarin.

Key words: Irrigation automation, drip irrigation scheduling, micro-irrigation, Nagpur mandarin.

Nagpur mandarin (*Citrus reticulata* Blanco) is an important citrus crop grown in 0.148 m ha area with production of 0.875 Mt. The average productivity is 10-11 t ha^{-1}, which very low compared to other mandarin cultivars, due to water stress, improper irrigation scheduling, surface irrigation method, lack of drip irrigation systems and inadequate soil moisture during the critical plant growth and fruit developmental stages. Due to increasing scarcity of water, the surface irrigation methods are being converted with drip irrigation systems but the system is not operated regularly maintaining the correct irrigation water and intervals. Due to manual operation the irrigation interval uniformly is not maintained properly and to increase 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 under tree drip irrigation systems (Shigure, 4; Shigure *et al*., 1) and he also studied the fruit quality with micro-jet irrigation (Shirgure, 5) and its irrigation schedule technology (Shirgure, 5) under central Indian conditions. The drip system has been successfully automated in the turf grass orchards equipped with solid jet permanent sprinkler irrigation system. Bolden *et al*. (1) studied 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. Eight to ten-year-old trees cv. Valencia on *Citrus aurantium* rootstock planted at 8 m × 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. He recorded the highest yield with irrigation at 85% moisture capacity and improved fruit quality also.

The micro-irrigation scheduling experiment automatic controller was conducted at Experimental Farm of NRCC, Nagpur during 2007-2010 with the objective to study the automatic irrigation scheduling through the drip irrigation and the effect on growth, yield and quality of 12-14 year-old bearing Nagpur mandarin (Fig. 1). 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 field capacity and permanent wilting point the field under study was 30.4 and 19.6% respectively. The available water content of the soil was 10.9%. The bulk density of the soil determined using core sampler was 1.34 g c/c. The water holding capacity of the

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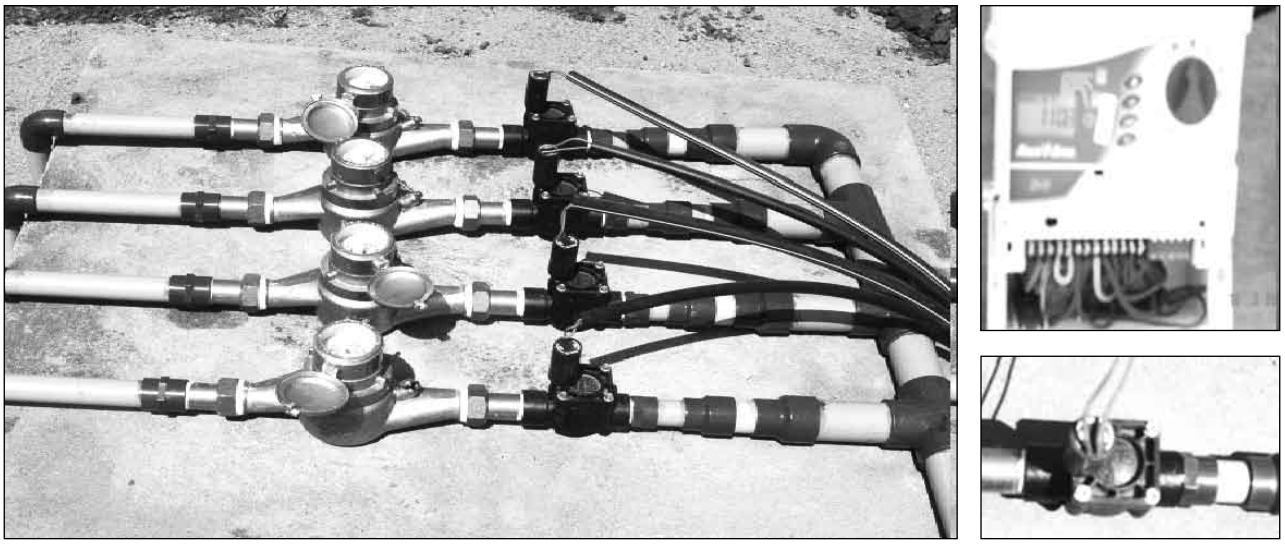

Fig. 1. The automatic drip irrigation scheduling hybrid stations controller (E-6) and solenoid valves

soil was 14.59 cm/m depth of soil. The Extra Simple Programming (ESP-6 (4-6 stations) automatically operated in three programmes independently having 6 start times and 4 control stations. The electrical control panel, pump control relays and hybrid station controller and solenoid valves with water meters were installed in the field. The Hybrid Station Controller (E-6, Rain Bird, USA) and Solenoid valve (Hunter, USA) the plants are irrigated more frequently and the soil moisture content at 0-30 cm depth in the root zone was ranged from 27.2-29.8%, which is 10-15% below the field capacity. The irrigations are scheduled 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 l per hour drippers (4/ plant) was installed in the field along with the other accessories. The increase in vegetative growth parameters, *i.e*. plant height, girth and canopy volume, were recorded in October. The stock girth was taken 15 cm above the soil surface and canopy volume of the mandarin tree was calculated using spread and canopy height using Castle's formula. The fruits harvested from each tree were weighed to express the yield by weight. Various fruit quality parameters, *viz*., total soluble solids (TSS) using hand refractometer, acidity, titrimetrically was determined as per standard procedures. The data was statistically subjected to analysis by Least Significant Difference (LSD) according to the standard method.

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 daily maximum open pan evaporation ranged from minimum 3.4 mm/day in December to maximum 12.7 mm/day in May. The daily weather data recorded from NRCC Observatory and the water budget fixed from 80-120% of the total during the different months of the year. Water quantity of the plant on daily basis during March 2007 to February 2009 was measured by water meters. The minimum quantity of water given to the mandarin plants was 46.9 to 55.4 l/ day per plant during November-December, 2007 and it was maximum, *i.e.*118.4 to 129.1 l/ day / plant during May 2008. The quantity of water scheduled using automatic drip irrigation and various duration daily and alternate day basis to the Nagpur mandarin plants was minimum (65.0 -72.4 l / day / plant) during October month and maximum (133.04-147.7 l / day/ plant) during May, 2008. 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. There was no much variation on monthly quantity of water applied to the mandarin plants as the automation scheduled equal amount of water. The moisture status at 30 cm depth during the different months in which the automatic micro-irrigation was at higher level (> 25% w.b.) in the automatic irrigation scheduled daily with 90 min. two times and automatic irrigation scheduled at alternate with 180 min. two times. The soil moisture was maintained between 15-25% in automatic irrigation scheduled daily with 60 min. three times and irrigation scheduled alternate day with 120 min. three times. The automatic irrigation

schedules maintained the higher soil moisture during the critical months from March to June. This clearly observed that soil moisture was maintained higher in automatic irrigation scheduled automatic irrigation daily with 90 min. interval two times and automatic irrigation daily with 180 min. interval two times, which have higher and continuous flow rates. The fluctuations over the period are also not observed. From the study it is also clear that the automatic irrigation schedule having 90 min. two times daily and 180 min. two times alternate days maintains higher soil moisture during the year 2007. The soil moisture was maintained higher uniform in automatic irrigation scheduled automatic irrigation daily with 90 min. interval two times and automatic irrigation at alternate day with 180 min. two times, which have higher and continuous flow rates during 2008.

The effect of different automatic irrigation scheduling had positive influence on the growth of Nagpur mandarin. The mean plant height and stock girth is 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 to 87.81 m^3 (Table 1). The average plant and stock girth was higher in automatic irrigation at alternate day with 120 min. three times followed by automatic irrigation daily with 90 min. interval two times. The canopy volume is significantly affected due the automatic micro-irrigated schedules and it was higher (87.81 m^3) in automatic irrigation scheduled alternate day with 120 min. 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 min. interval three times (66.6 m^3) and automatic irrigation scheduled daily with 90 min. interval two times (64.56 m^3) during the year 2007-10. This is mainly due to availability of constant and continuous soil moisture in plant root zone.

The automatic controller based drip irrigation schedule having 1-3 h duration and two to three pulse a day has profound effect on the yield and fruit quality of the Nagpur mandarin during 2007-10. Yield and quality of Nagpur mandarin fruits was significantly influenced by the different automatic irrigation schedules. The fruits per plant, fruit yield (tonnes/ ha) and TSS was found significant during 2008-09 and 2009-10. The juice percent was also found significant in harvesting season of 2008-09. 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. Hence, significant difference was not observed on the average weight of the fruits (Table 2). The average number of fruits per plant, yield, TSS, juice content, acidity and TSS: acid ratio were analysed for the study period and pooled data is presented (Table 3). All the yield as well as fruit quality data was significant with respect to the differential automatic drip irrigation schedules. The number of fruits per plant was highest (726) in the automatic irrigation at alternate day with 120 min. three times followed by automatic irrigation daily with 90 min. 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 min. three times, *i.e*., 30.9 tonnes/ ha. The moderate yield was observed in automatic drip irrigation daily with 90 min. interval two times (30.1 tonnes/ha) followed by automatic drip irrigation daily with 180 min. interval two times (27.1 tonnes/ha). The lowest fruit yield was seen in irrigation scheduled daily having 60 min and three times indicating 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 resulted into good

Table 1. Plant height, stock girth and canopy volume of Nagpur mandarin under different irrigation schedules.

Treatment	Plant height (m)				Stock girth (cm)				Canopy volume (m^3)			
	2007	2008	2009	Mean	2007	2008	2009	Mean	2007	2008	2009	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	0.08	NS	NS	NS	0.02	13.61	15.40	11.12	1.34

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

Table 2. Fruit yield and quality of the Nagpur mandarin under different irrigation schedules.

Treatment	Fruits/tree			Fruit yield (tonnes/ha)			Av. fruit wt. (g)			TSS (°Brix)			Juice (%)			Acidity (%)		
	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
I_1	467	368	982	16.85	16.65	40.01	130.05	162.32	147.19	10.20	9.17	9.77	32.94	46.05	36.94	0.7	0.9	0.88
I_2	607	638	997	23.58	29.38	37.38	140.25	164.04	151.58	9.30	9.4	9.78	33.90	40.6	38.55	0.7	0.87	0.87
I_3	478	744	956	19.86	32.83	40.06	149.81	159.67	151.54	10.00	10.2	10.45	36.00	43.88	42.44	0.7	0.93	0.78
I_4	423	724	767	16.64	32.41	32.07	142.00	162.92	151.76	10.20	9.11	10.44	31.30	41.92	40.57	0.7	0.94	0.80
$CD_{(P = 0.05)}$	NS	158	14	NS	0.94	1.65	NS	NS	NS	NS	0.77	0.53	NS	NS	1.54	NS	NS	NS

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

quality fruits and yield. High fruit growth rate was seen in automatic irrigation at alternate day with 180 min. two times during 2007-08 and 2008-09. The highest average fruit weight (153.7 g.) and lowest acidity (0.78%) is observed in the automatic drip irrigation at alternate day with 120 min. three times. The TSS (10.22°Brix) and juice percent (40.7) was more in the automatic drip irrigation at alternate day with 120 min. three times (Table 3). The TSS/acid ratio is indicator of sweetness of the fruit of *Ambia* flush during October-November month. If the TSS: acid ratio is high means that the fruits have more TSS and less acidity. This ratio was analysed for all the treatments (Table 3). The highest TSS/acid ratio was found in the automatic drip irrigation at alternate day with 120 min. three times (13.2) followed by automatic drip irrigation at alternate day with 180 min. two times (12.4). The lowest TSS/acid (11.7) was observed in automatic drip irrigation with 60 min. three times daily. Similar results on drip automation were reported on different citrus cultivars by Ferguson and Israel (2) and Sardo (3).

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Table 3. The average fruit yield and quality of the Nagpur mandarin under different irrigation schedules.

Treatment	No. of fruits/ plant	Yield (tonnes/ha)	TSS (°Brix)	Av. fruit wt. (g)	Juice (%)	Acidity (%)	TSS/acid 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

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

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