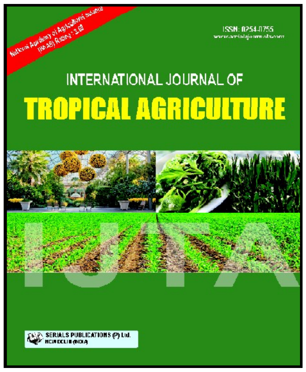

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Growth, Yield and Water Use Efficiency as Influenced by Irrigation Scheduling in Banana (*Musa* spp., AAA group) var. Grand Naine During Water Deficit Period in Terai Zone of West Bengal

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Abstract: An experiment was carried out to study the growth and yield dynamics in proportion with moisture availability regulated by method and irrigation intervals during 2012-2014 at UBKV, Pundibari. The plant height (221.32 cm and 212.83 cm), pseudostem girth (75.25 cm and 71.65 cm), number of leaves (22.48 and 20.60), leaf area (0.93 m^2 and 0.82m^2), yield (56.74 t/ha and 54.92 t/ha), water use efficiency (0.143 t/ha/cm and 0.139 t/ha/cm) was recorded highest at weekly interval in plant and ratoon crops, respectively at the time of shooting whereas in control plots the lowest plant height (206.01 cm and 197.43 cm), pseudostem girth (69.22 cm and 65.52 cm), number of leaves (18.16 and 16.27), leaf area (0.76 m^2 and 0.66 m^2), yield (54.92 t/ha and 43.71 t/ha), water use efficiency (0.115 t/ha/cm and 0.113 t/ha/cm) was recorded in plant and ratoon crops, respectively at the time of shooting. The moisture deficit for banana at any stage of the crop reflects the bunch yield which can be substituted by weekly or biweekly irrigation intervals to avoid moisture stress.

Key words: Banana, Irrigation, Growth, Yield.

INTRODUCTION

Banana is one of the most important fruit crop in India and accounts for 31.7 % of the total fruit production. It is widely cultivated in varying agroclimatic regions under different systems of production (Mustaffa, 2011). In West Bengal, the farmers are cultivating local cultivars which are low yielders. The productivity in the state is 24.1 t/ha as against 64.1 t/ha in Gujarat (Anon., 2013). Despite of enormous economic importance of banana, its internal water relations have been seriously neglected due to the practical difficulties of making the necessary measurements. Similarly in West Bengal, especially in the Terai region, yield reduction might be due to neglecting irrigation during water deficit period (December-February). Insufficient water supply results in reduced plant growth, yield and fruit quality due to water stress (Durgadevi and Jeyakumar, 2001). Optimizing water applications by scheduling irrigation, increases water conservation, reduce production costs and increase growth and yield. Irrigation scheduling is thus especially important in Terai region for banana as net returns in the regularly irrigated bananas are normally higher than those which are not irrigated (Durgadevi and Jeyakumar, 2001). Therefore, to standardize the production of tissue cultured Grand Naine banana for Terai zone of West Bengal through irrigation scheduling during water deficit period (December –February).

MATERIALS AND METHODS

An experiment was conducted at Instructional farm, U.B.K.V., Pundibari, West Bengal during the year 2012-2014 in tissue culture banana var. Grand Naine planted at a spacing of 2 × 2 m. The experiment was laid out in split plot design replicated thrice having methods of irrigation (furrow and basin) as main plots and irrigation scheduling at four levels *i.e.* Control (No irrigation) weekly interval (11 irrigations), biweekly interval (6 irrigations), triweekly interval (4 irrigations). The leaf length and breadth was measured in centimetre. Length was measured at three different points parallel to each other starting from lamina base to its apex along the midrib in fully open condition to calculate the average length of the three points. Similarly, breadth was also measured at base, centre and apex of the leaf lamina. The average value of length and breadth thus obtained was multiplied to express the area of the leaf in square metre. The yield per plant was weighed in kilo gram. WUE was estimated following (Stanhill, 1986) and expressed as t/ha/cm.

$$WUE = \frac{Y(\text{t/ha})}{ET(\text{cm})}$$

where Y is marketable yield and ET is crop evapotranspiration.

The yield per hectare was calculated and expressed in t/ha.

The climatic data and irrigation requirement (ET_{crop}) during the plant and ratoon crop period was presented in table 1-3.

Table 1
Climate data during the plant crop period

	Temperature			
Months	*Max. (°C)*	*Min. (°C)*	*Mean Relative Humidity (%)*	*Total rainfall (cm)*
June, 2012	30.83	25.60	89.11	33.94
July	30.99	25.77	87.19	23.40
August	32.22	25.80	85.87	18.16
September	30.89	24.68	87.58	23.62
October	30.38	20.22	79.74	0.71
November	27.74	13.96	72.35	0.00
December	23.13	11.68	79.79	0.00
January, 2013	22.11	7.96	75.27	0.00
February	26.69	12.34	72.14	0.00
March	30.27	16.72	70.37	0.00
April	30.33	20.15	74.80	4.08
May	30.44	23.08	84.82	8.10
June	32.30	25.38	86.66	13.47
July	31.74	25.86	88.08	24.44
August	32.02	25.32	87.37	11.07
September	31.81	24.61	87.00	13.47
October	29.09	21.08	85.79	5.45

Table 2
Climate data during the ratoon crop period

	Temperature			
Months	*Max. (°C)*	*Min. (°C)*	*Mean Relative Humidity (%)*	*Total rainfall (cm)*
November, 2013	27.74	13.96	72.35	0.00
December	23.13	11.68	79.79	0.00
January, 2014	22.11	7.96	75.28	0.00
February	22.17	11.12	56.83	1.95
March	28.48	15.32	61.27	1.45
April	30.05	19.87	76.00	12.40
May	29.87	22.50	85.50	25.50
June	31.79	24.20	87.00	41.00
July	31.00	25.77	87.71	18.43
August	33.00	25.80	85.93	13.22

The climate of the experimental site is characterized by heavy rains (April to September) followed by a long dry spell (October to March) and moderate temperature and it was normal during the study period presented in table no. 1 and 2. The required volume of water was applied manually with buckets for respective furrows and basins (table 3). The significance of results of the data was subjected to analysis of variance given by Gomez and Gomez (1984) employing the 'op-stat' software package.

RESULTS AND DISCUSSION

In plant crop, increasing the irrigation interval from 7 to 21 days interval significantly decreased the height (65.24 cm, 62.12 cm and 60.65 cm at 7th month, 118.66 cm, 108.98 cm, and 98.81 am at 9th month and 221.32 cm, 211.81 and 207.99 cm at shooting) and girth (32.14 cm, 30.65 cm and 27.77 cm at 7th month, 46.40 cm,43.57 cm and 38.37 cm at 9th month, 75.25 cm, 71.09 cm and 69.76 cm at shooting) of pseudostem throughout the crop growth period while irrigating the crop through basin method also resulted into significantly higher pseudostem height (52.92 cm and 70.50 cm at 7th month, 101.44 cm, 110.12 cm at 9th month and 201.72 cm and 221.84

Table 3
Irrigation requirement (ET_{crop}) during water deficit period in plant and ratoon crop

		Irrigation depth (cm)	
Date	*ET crop (cm)*	*Furrow*	*Basin*
		Plant crop	
08 June to 24 Nov 2012	32.98	65.97	54.97
25 Nov 12 to 2nd Jan 13	7.11	14.21	11.84
03-09th Jan, 2013	1.33	2.73	2.27
10-16th Jan, 2013	1.38	2.77	2.31
17-23rd Jan, 2013	1.38	2.54	2.12
24-31st Jan, 2013	1.27	2.25	1.87
1-07th Feb, 2013	1.12	2.48	2.07
08-14th Feb, 2013	1.24	2.85	2.37
15-21st Feb, 2013	1.43	2.66	2.21
22-28th Feb, 2013	1.33	3.02	2.52
01-07th Mar, 2013	1.51	2.87	2.39
08-14th Mar, 2013	1.44	3.05	2.54
15th Mar to Nov 8th 2013 (no irrigation)	90.22	–	–
15th Mar to Oct 8th 2013 (Weekly)	80.38	–	–
15th Mar to Oct 19th 2013 (Weekly)	83.58	–	–
15th Mar to Nov 4th 2013 (Triweekly)	88.67	–	–
Total	396.37	–	–
		Ratoon crop	
July 8th to Nov 30th 2013	28.23	56.46	47.05
Dec 1st to Dec 29th 2013	6.20	12.40	10.33
Dec 30st to Jan 2nd 2014	0.88	1.76	1.46
03-09th Jan, 2014	1.24	2.48	2.06
10-16th Jan, 2014	1.32	2.64	2.20
17-23rd Jan, 2014	1.34	2.68	2.30
24-31st Jan, 2014	1.21	2.42	2.01
1-07th Feb, 2014	1.10	2.20	1.83
08-14th Feb, 2014	1.22	2.44	2.03
15-21st Feb, 2014	1.41	2.82	2.35
22-28th Feb, 2014	1.32	2.64	2.20
01-07th Mar, 2014	1.11	2.22	1.85
08-14th Mar, 2014	1.22	2.44	2.03
15th Mar to Aug 28th 2014 (no irrigation)	67.48	134.96	112.46
Total	396.37	–	–

cm at shooting) and girth (24.34 cm and 33.61 cm at 7th month, 41.36 cm and 41.01 cm at 9th month and 68.36 cm and 74.30 cm at shooting) at all stages of the crop growth. Lowest (58.84 cm, 96.67 cm and 206.01 cm at 7th, 9th and shooting, respectively) reading of these parameters were recorded with no irrigation as compared to three irrigation intervals at all the stages of the crop growth.

Providing irrigation at weekly interval was significantly better than providing no irrigation and also better than increasing the interval at all stages though not always significant during the crop growth. Providing no irrigation or providing irrigation at 21 days interval had similar effect while irrigating the crop at weekly interval produced best results. The overall interaction effect of irrigation scheduling and method on height and girth however was non-significant. The pseudostem height and girth of ratoon crop also exhibited similar trend as its plant crop with irrigation scheduling, irrigation methods and their interaction. Similarly effect of irrigation treatments was reported significant on pseudostem height and girth (Khalifa, 2012).

Number of leaves

Both basin irrigated plant and ratoon crop produced more leaves (green + dry) than the crop irrigated with furrows though the difference was significant only at shooting stage *i.e.* the basin irrigated plant and ratoon crop finally produced 22.24 and 20.36 leaves per plant, respectively while furrow irrigated crop produced 18.32 and 16.43 leaves per plant, respectively (table 6).

Table 4
Effect of method of irrigation and scheduling on pseudostem height (cm) of plant and ratoon crop

	7th month			*9th month*			*At shooting*		
	FM	*BM*	*Mean*	*FM*	*BM*	*Mean*	*FM*	*BM*	*Mean*
Plant crop									
No irrigation	48.98	68.70	58.84	89.22	104.12	96.67	197.14	214.88	206.01
Weekly	56.23	74.25	65.24	121.56	115.76	118.66	214.60	228.05	221.32
Biweekly	53.73	70.51	62.12	105.35	112.61	108.98	198.13	225.48	211.81
Triweekly	52.76	68.55	60.65	89.64	107.97	98.81	197.02	218.96	207.99
Mean	52.92	70.50		101.44	110.12		201.72	221.84	
Ratoon crop									
No irrigation	45.00	64.50	54.74	82.26	97.42	89.84	188.46	206.40	197.43
Weekly	52.03	69.84	60.93	114.87	109.07	111.96	206.12	219.56	212.83
Biweekly	49.73	66.31	58.01	98.65	105.92	102.28	189.36	217.00	203.17
Triweekly	48.56	64.34	56.45	82.95	101.49	92.21	188.55	210.06	199.30
Mean	48.82	66.24		94.68	103.47		193.12	213.25	
$CD_{P=0.05}$									
M			2.90/2.94*			3.75/1.96*			14.10/12.55*
I			2.61/2.55*			5.56/5.79*			NS/NS*
M × I			NS/NS*			7.87/8.30*			NS/NS*

FM-furrow method, BM-basin method, M-irrigation method, I-Irrigation schedule, *Ratoon crop.

Table 5
Effect of method of irrigation and scheduling on pseudostem girth (cm) of plant and ratoon crop

	7th month			*9th month*			*At shooting*		
	FM	*BM*	*Mean*	*FM*	*BM*	*Mean*	*FM*	*BM*	*Mean*
Plant crop									
No irrigation	21.36	29.35	25.35	35.62	37.18	36.40	64.95	73.49	69.22
Weekly	27.59	36.70	32.14	48.63	44.18	46.40	75.28	75.23	75.25
Biweekly	25.59	35.70	30.65	43.96	43.19	43.57	67.95	74.23	71.09
Triweekly	22.84	32.70	27.77	37.23	39.51	38.37	65.28	74.24	69.76
Mean	24.34	33.61		41.36	41.01		68.36	74.30	
Ratoon crop									
No irrigation	17.96	25.95	21.95	31.80	33.38	32.59	61.15	69.89	65.52
Weekly	24.19	33.30	28.74	44.82	40.38	34.57	71.68	71.63	71.65
Biweekly	22.20	32.30	27.25	40.15	39.20	39.67	64.35	70.44	67.39
Triweekly	19.44	29.30	24.37	33.43	35.71	34.57	61.68	70.63	66.15
Mean	20.94	30.21		37.55	37.16		64.71	70.64	
$CD_{P=0.05}$									
M			3.50/3.48*			NS/NS*			4.72/3.67*
I			2.81/2.81*			3.19/3.87*			3.04/3.65*
M × I			NS/NS*			NS/NS*			4.99/NS*

FM-furrow method, BM-basin method, M-irrigation method, I-Irrigation schedule, *Ratoon crop

Irrigating both the plant and ratoon crop at weekly interval produced more leaves per plant at all stages which was significant as compared to the crop with no irrigation and the crop irrigated at 21 days interval. The crop finally produced (at shooting) 18.16 and 19.35 leaves per plant with no and triweekly irrigation, respectively which was at par statistically, similarly 22.48 and 21.12 leaves per plant, statistically at par was recorded at shooting in the plants irrigated weekly and biweekly, respectively. Corresponding values for ratoon crop recorded were 16.27, 17.46, 20.60 and 19.25 leaves per plant, respectively. No significant interaction of scheduling and method of irrigation were however observed for number of leaves produced by the crop at all growth stages.

Similar results were also reported by Shanmugavelu *et al.* (1992); Krishnakutty *et al.* (1995); Turner and Thomas (1998); Durgadevi and Jayakumar (2001) and Khalifa (2012) that banana is sensitive to soil water deficits effecting expanding tissues either through reducing number of leaves or emerging leaves.

Leaf area (m^2) (length × breadth)

Irrigation scheduling significantly influenced the leaf area of both plant and ratoon crop showing similar trend as was observed for length and breadth, finally producing highest leaf area of 0.93 and 0.82 m^2, respectively at shooting when the crop was irrigated weekly followed by the crop irrigated biweekly (0.84 and 0.74 m^2, respectively), triweekly (0.81 and 0.71m^2, respectively) and least with no irrigation (0.76 and 0.66 m^2, respectively). Similar trend on leaf area was also observed with irrigation methods and interaction as was observed with length and breadth

Table 6
Effect of method of irrigation and scheduling on leaves per plant of plant and ratoon crop

	7th month			*9th month*			*At shooting*		
	FM	*BM*	*Mean*	*FM*	*BM*	*Mean*	*FM*	*BM*	*Mean*
Plant crop									
No irrigation	14.24	14.46	14.35	16.89	17.46	17.17	15.32	21.01	18.16
Weekly	15.98	15.74	15.85	20.22	19.75	19.98	20.98	23.99	22.48
Biweekly	14.74	15.22	14.97	19.58	19.66	19.62	19.77	22.49	21.12
Triweekly	13.84	15.49	14.66	18.23	18.43	18.33	17.23	21.48	19.35
Mean	14.69	15.22		18.73	18.82		18.32	22.24	
Ratoon crop									
No irrigation	13.90	14.13	14.0	15.89	16.48	16.18	13.43	19.12	16.27
Weekly	15.87	15.41	15.64	19.25	18.78	19.01	19.10	22.11	20.60
Biweekly	14.41	14.89	14.64	18.60	18.68	18.64	17.88	20.63	19.25
Triweekly	13.51	15.16	14.33	17.25	17.45	17.35	15.34	19.59	17.46
Mean	14.42	14.89		17.74	17.85		16.43	20.36	
$CD_{P=0.05}$									
M			NS/NS*			NS/NS*			1.88/1.34*
I			0.82/0.89*			1.33/1.18*			1.54/1.65*
M × I			NS/NS*			NS/NS*			NS/NS

FM-furrow method, BM-basin method, M-irrigation method, I-Irrigation schedule, *Ratoon crop.

i.e. non-significant during shooting stage and significant during vegetative stage of both plant and ratoon crop.

Water stress was also reported to reduce leaf area in banana as leaf area development is based on its length and width (Turner, 1981, 1998; Krishna Surendar *et al.*, 2013_a). The leaf length of banana reduced during water stress situation is due to reduced cell division and cell enlargement and is thus associated with reduced organ development (Gardner *et al.*, 1981; Krishna Surendar *et al.*, 2013_a).

This is because leaf area increases with an increase in water supply making the plants to perform photosynthesis efficiently (Levy *et al.*, 1978). This in turn increases the accumulation of photosynthetates accelerating growth. The effect on growth parameters thus clearly indicates that water is important for biochemical and physiological process that lead to organ growth, development and differentiation (Turner, 1972). A reduction in leaf area reduces biomass accumulation and decreases leaf elongation and growth during water stress resulting in preferential partitioning of photosynthates to the roots and shoots reducing leaf area development (Krishna Surendar *et al.*, 2013_a).

Leaf area of a crop is associated with its chlorophyll content which influences the photosynthetic rate in banana under water stress due to reduction in stomatal conductance (Carter, 1991; Bhattacharya and Madhava Rao, 1988; Krishna Surendar *et al.*, 2013_b) that determine yield (Alluwar and Deotale, 1991). Water stress results a fall in leaf

Table 7
Effect of method of irrigation and scheduling on leaf area (m^2) of plant and ratoon crop

	7th month			*9th month*			*At shooting*		
	FM	*BM*	*Mean*	*FM*	*BM*	*Mean*	*FM*	*BM*	*Mean*
Plant crop									
No irrigation	0.22	0.10	0.15	0.27	0.12	0.19	0.74	0.79	0.76
Weekly	0.30	0.13	0.21	0.34	0.17	0.26	0.89	0.97	0.93
Biweekly	0.27	0.11	0.19	0.31	0.15	0.23	0.85	0.85	0.84
Triweekly	0.23	0.11	0.17	0.32	0.18	0.25	0.82	0.81	0.81
Mean	0.25	0.11		0.30	0.15		0.82	0.85	
Ratoon crop									
No irrigation	0.19	0.08	0.13	0.23	0.09	0.15	0.64	0.69	0.66
Weekly	0.28	0.11	0.19	0.30	0.14	0.21	0.78	0.86	0.82
Biweekly	0.24	0.09	0.16	0.26	0.12	0.19	0.75	0.75	0.74
Triweekly	0.21	0.09	0.14	0.27	0.15	0.21	0.72	0.71	0.71
Mean	0.22	0.09		0.26	0.12		0.72	0.75	
$CD_{P=0.05}$									
M			0.043/0.066*			0.017/0.008*			NS/NS*
I			0.019/0.018*			0.021/0.020*			0.100/0.092*
M × I			0.034/0.033*			NS/NS*			NS/NS*

FM-furrow method, BM-basin method, M-irrigation method, I-Irrigation schedule, *Ratoon crop.

area thus decrease its chlorophyll and photosynthetic activity (Alberte *et al.*, 1977; Thimann, 1980; Makhmudov, 1983; Asharaf and Mahmood, 1990; Chen and Creeb, 1991; Dekov *et al.*, 2000) and increasing the intensity of water stress like through extending the irrigation interval especially during water deficit period, increase the chlorophyll a/b ratio (Zhu and Huang, 1994).

The yield of plant and ratoon crop banana cv. Grand Naine was not influenced by the methods of irrigation *i.e.* statistically similar yield (49.87 and 47.94 tha^{-1} and 51.92 tha^{-1} 49.98 tha^{-1}, respectively) was recorded with furrow and basin method as most of the vegetative growth parameters and yield attributes were also not significantly influenced by the method irrigation applied (table 8).

The yield decreased gradually but significantly with subsequent increase of 7 days from weekly to triweekly interval and no irrigation with a yield reduction of 8.74 and 9.45%, 12.69 and 13.56% and 19.77 and 20.41% for plant and ratoon crop from the yield of 56.74 and 54.92 tha^{-1}, respectively recorded with weekly irrigation scheduling. Further yield of crop was highest when the crop was basin irrigated weekly (57.25 and 55.20 tha^{-1}, respectively for plant and ratoon crop) followed by 56.24 and 54.65 tha^{-1}, respectively for plant and ratoon crop with weekly furrow irrigated crop though not differing significantly. The quantum of this much yield reduction in banana var. Grand Naine either with no irrigation or extending irrigation interval indicates that irrigation at weekly interval either through basin or furrow method during dry spell

(December–February) in Terai zone of West Bengal when no or very less rainfall occurs is very much essential to attain optimum physiological growth and better yield of this banana cultivar. Similarly as almost all the vegetative growth parameters and yield attributes were significantly influenced by scheduling irrigation so was the yield as was also reported by Daniells *et al.* (1987) and Khalifa (2012).

Table 8
Effect of method of irrigation and scheduling on yield of plant and ratoon crop

	Yield (t/ha)					
	Plant crop			*Ratoon crop*		
	FM	*BM*	*Mean*	*FM*	*BM*	*Mean*
No irrigation	42.90	48.16	45.52	40.85	46.59	43.71
Weekly	56.24	57.25	56.74	54.65	55.20	54.92
Biweekly	52.04	51.53	51.78	49.99	49.48	49.73
Triweekly	48.31	50.78	49.54	46.26	48.69	47.47
Mean	49.87	51.92		47.94	49.98	
$CD_{P=0.05}$						
M		NS			NS	
I		1.88			2.68	
M × I		3.41			NS	

FM-furrow method, BM-basin method, M-irrigation method, I-Irrigation schedule.

It was reported that moisture stress at any stage of the growth of banana reduced the productivity by 30-50 % (Krishna Surendar *et al.*, 2013_b). The plant growth and yield decreased drastically when the interval between watering was increased with the soil moisture falling below 66% of total available soil moisture (Robinson and Bower, 1998). Irrigating bananas at 5-10 days interval in dry weather (Naik, 1949) or 10-15 days interval from October to February and 6-8 days interval from March to May (Gandhi, 1952) was long back recommended. It was observed that soil moisture content falling about 10 % from the field capacity or the available moisture content both at depth 0-20 and 20-40 cm in no irrigated plots whereas in the weekly irrigated plots the soil moisture content was maintained at field capacity estimated as about 37-43 and 35-39 %, respectively. The crop water requirement based on crop evapotranspiration (ET_{crop}) of banana Grand Naine was estimated at 396.37 cm for the total cropping period in Terai zone of West Bengal, 13.43 cm of which should be distributed in 11 irrigation applications either through basins or furrows at weekly interval during the rain deficit period. Similarly seasonal irrigation of Cavendish Dwarf bananas in west coast of Cyprus with 1200-1300 mm (Metochis, 1999) and 764.3 mm per year for banana Grand Naine in Maharashtra, India (Mahmoud, 2013) of water proved sufficient. The water requirement of banana was reported to range between 5-50 cm per month depending on soil and climatic conditions (Simmonds, 1966). Krishnasastry *et al.* (1985) estimated water consumption throughout the crop growth period of Robusta banana at 2150 mm to produce best results maintaining 20% depletion of available soil moisture.

This indicates that to maintain the productivity of banana var. Grand Naine in Terai zone of West Bengal the soil moisture content during the water deficit period should be maintained around 37-43% at 0-20 cm and 35-39% at 20-40 cm to realize higher yield and reduction of soil moisture content below this range or by 10% will significantly reduce yield as was estimated for the crop where no irrigation was applied. The most suitable soil moisture content for the banana crop was reported in the range of 50-60% available soil moisture (Chen and Ching-Yih, 1971). It was reported from Jordan valley, Israel, the range between field capacity and two-third of total available water constitute the optimum range of soil moisture for Cavendish bananas with regard to both physiological activity and yield (Shmueli, 1953). Banana var. Grand Naine planted on June was at pre-flowering stage when there was water stress condition from January to March due to no rain and it was reported that the most critical period of moisture stress is from pre-flowering stage to before ripening (Bredell, 1970) and thus no irrigation during this period significantly reduced yield and the yield progressively reduced as irrigation interval was increased from 7-21 days.

Water use efficiency (WUE) also was not significantly influenced by methods of irrigation but significantly influenced by irrigation scheduling and their interaction in plant and ratoon crop (table 9). The water use efficiency estimated for plant and ratoon crop irrigated with furrow method was 0.126 and 0.120 t/ha/cm, respectively while in basin method it was 0.131 and 0.120 t/ha/cm, respectively and is statistically at par. Both the plant and ratoon crop irrigated weekly had highest water use efficiency of 0.143 and 0.139 t/ha/cm signifying that every unit depth of water used by the crop yielded 0.143 t/ha which was significantly efficient in terms of water use than the crop irrigated biweekly (0.129 and 0.126 t/ha/cm, respectively); triweekly (0.126 and 0.119 t/ha/cm, respectively) and least efficient was when the crop was not irrigated (0.115 and 0.113 t/ha/cm, respectively).

Table 9
Effect of method of irrigation and scheduling on water use efficiency (t/ha/cm) in plant and ratoon crop

	Plant crop			*Ratoon crop*		
	FM	*BM*	*Mean*	*FM*	*BM*	*Mean*
No irrigation	0.108	0.122	0.115	0.016	0.120	0.113
Weekly	0.142	0.144	0.143	0.140	0.138	0.139
Biweekly	0.130	0.128	0.129	0.128	0.124	0.126
Triweekly	0.122	0.130	0.126	0.116	0.122	0.119
Mean	0.126	0.131		0.120	0.120	
$CD_{P=0.05}$						
M			NS			NS
I			0.005			0.007
M × I			0.009			NS

FM-furrow method, BM-basin method, M-irrigation method, I-Irrigation schedule

This shows that improvements in water use efficiency could come from a closer match between plant water use and amount of water applied (Krishna Surendar *et al.*, 2013_b). Similarly, water use efficiency of 28-37 kg/ha/mm for cv. Robusta (Hedge and Srinivas (1989); 2.54 kg per 1000 litres of water for cv. Poovan (Durgadevi and Jayakumar, 2001); 11.7 kg/ha/mm for banana cv. Pacovan (Bassoi *et al.*, 2004) and 40-60 kg/ha per 100 m^3 of water used for plantain (Akinro *et al.*, 2012) was reported. Further as earlier discussed in section 4.1.7 productivity, in other words it can be stated that for terai zone of West Bengal to get a maximum water use efficiency, irrigation should be applied to the crop at weekly interval during the water deficit period to maintain the soil moisture content around 37-43 % at 0-20 cm and 35-39 % at 20-40 cm and reduction of soil moisture content below this range or by 10 % will significantly decrease the water use efficiency. Therefore it can be concluded that moisture deficit for banana at any stage of the crop reflects the bunch yield which can be substituted by weekly or biweekly irrigation intervals to avoid moisture stress.

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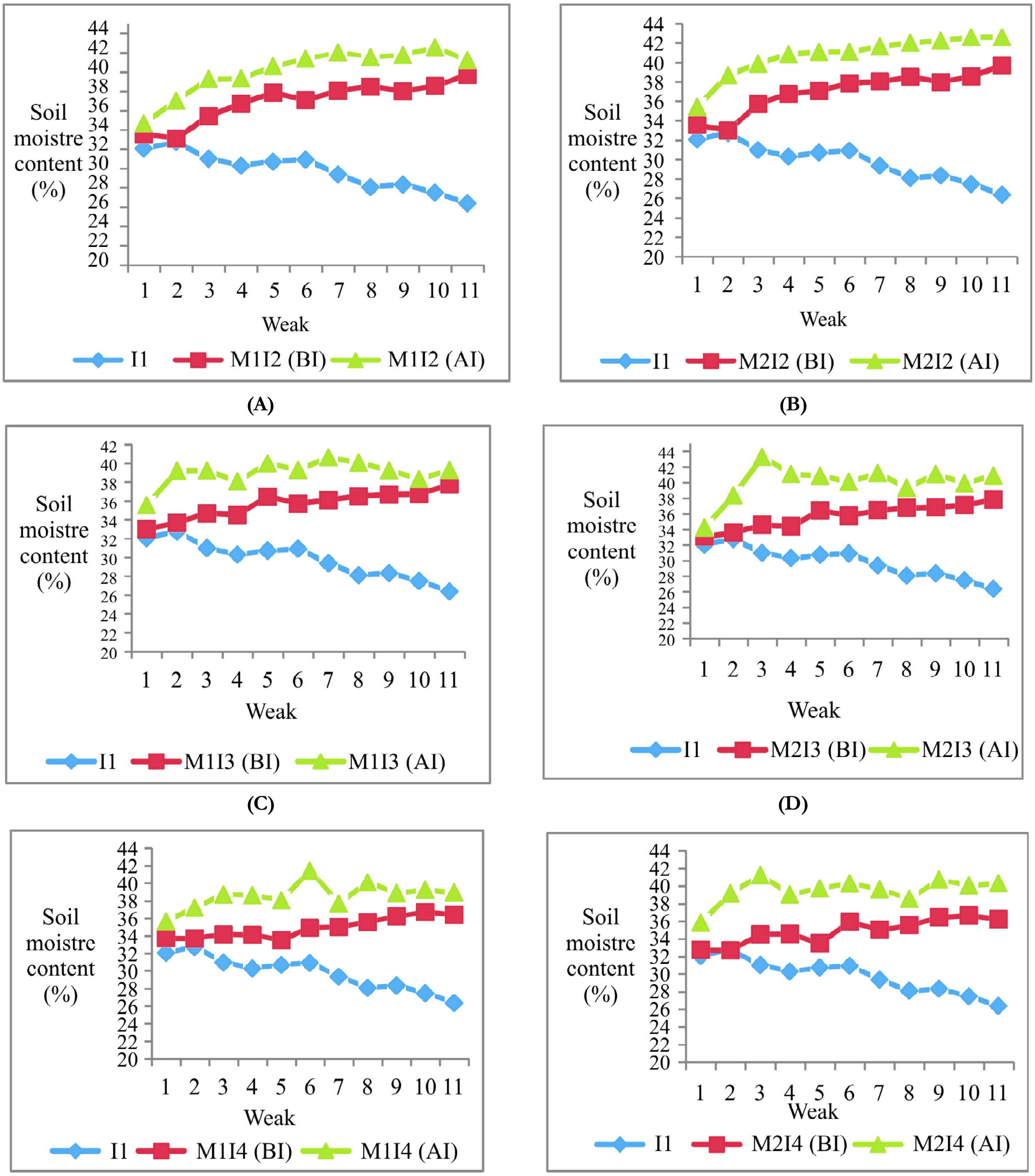

Figure 1: Weekly variations in soil moisture contents in weekly furrow and basin irrigation during water deficit period (at 0-20 cm (A-F) depth of soil)

I_1-no irrigation, M_1I_2-furrow method and weekly irrigation (A), M_2I_2-basin method and weekly irrigation (B); M_1I_3-furrow method and biweekly irrigation (C), M_2I_3-basin method and biweekly irrigation (D); M_1I_4-furrow method and triweekly irrigation (E), M_2I_4-basin method and triweekly irrigation (F); BI-before irrigation, AI-after irrigation.

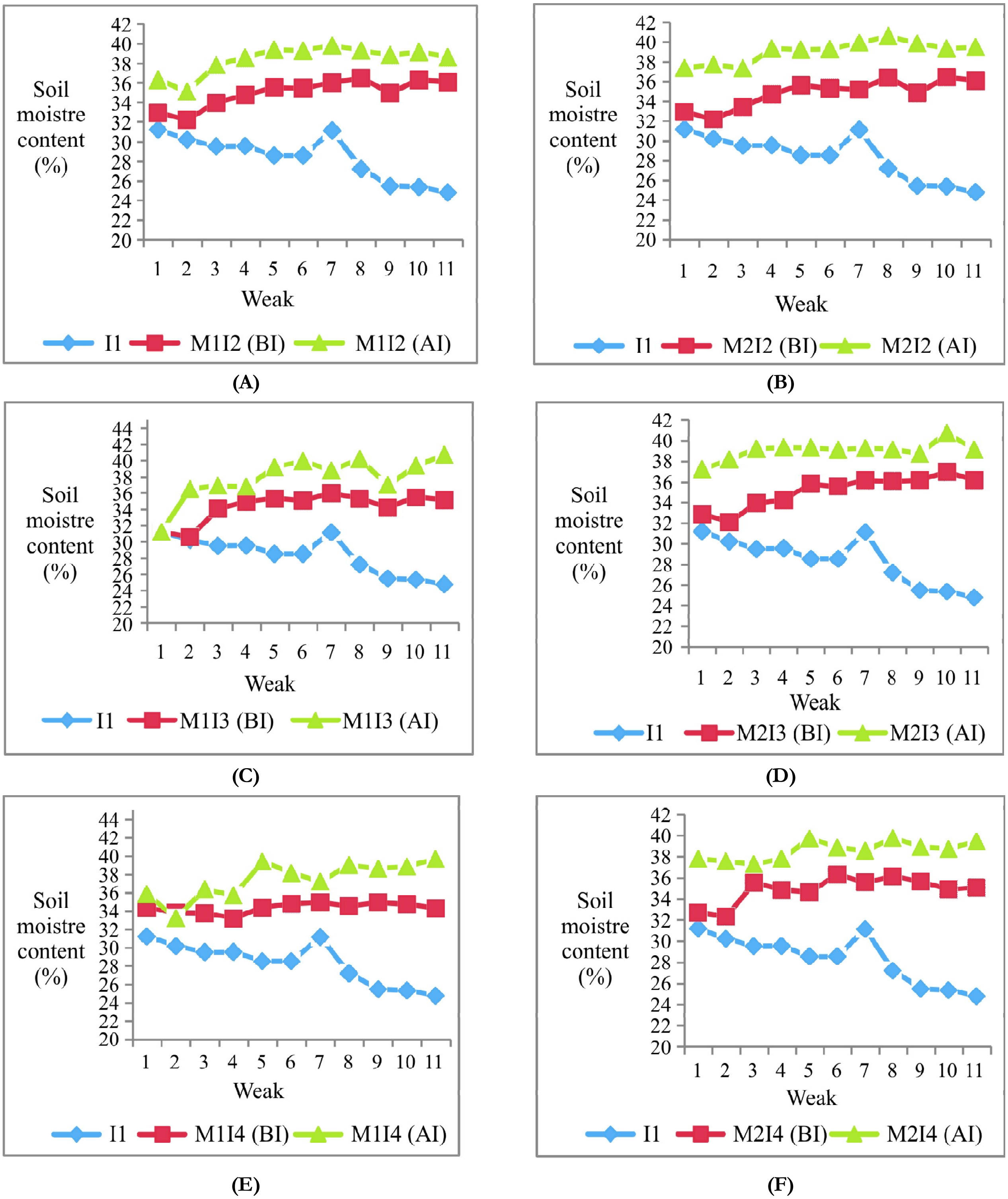

Figure 2: Weekly variations in soil moisture contents in weekly furrow and basin irrigation during water deficit period (at 20-40 cm (A-F) depth of soil)

I_1-no irrigation, M_1I_2-furrow method and weekly irrigation (A), M_2I_2-basin method and weekly irrigation (B); M_1I_3-furrow method and biweekly irrigation (C), M_2I_3-basin method and biweekly irrigation (D); M_1I_4-furrow method and triweekly irrigation (E), M_2I_4-basin method and triweekly irrigation (F); BI-before irrigation, AI-after irrigation

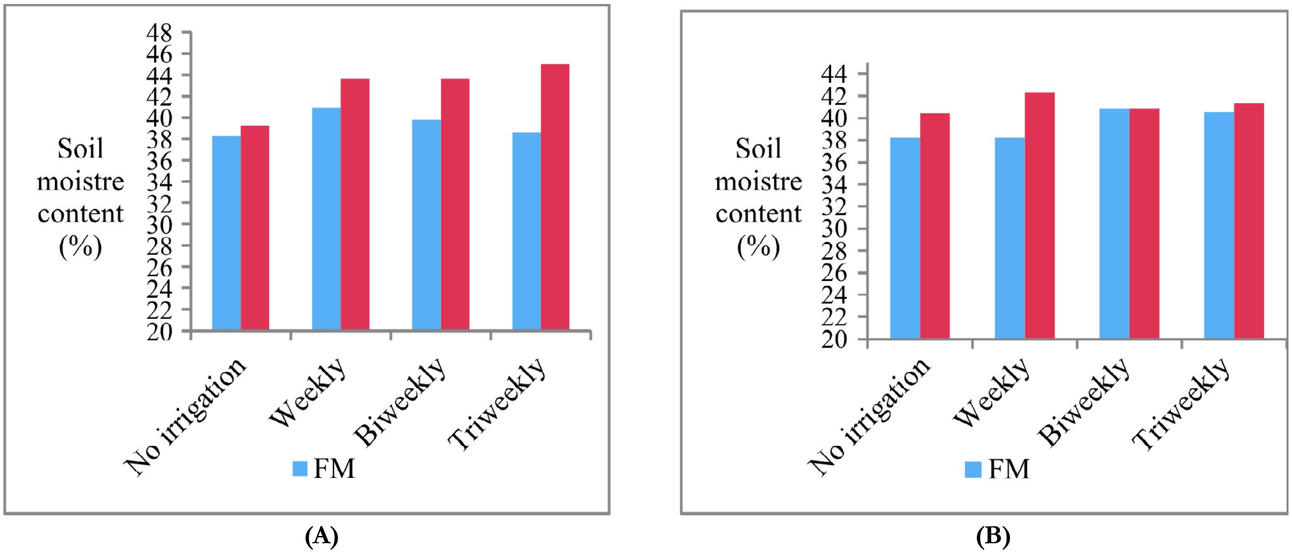

Figure 3:Soil moisture contents in furrow and basin irrigation during rainy period (at 0-20 cm (A) and 20-40 cm (B) depth of soil)

FM-furrow method, BM-basin method

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