Indian Journal of Agricultural Sciences **84** (5): 595–601, May 2014/Article
https://doi.org/10.56093/ijas.v84i5.40481

Effect of irrigation and nutrient management on growth, fibre yield and water use of ramie (*Boehmeria nivea*)

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Received: 31 December 2012; Revised accepted: 4 March 2014

ABSTRACT

The experiment was conducted at Research Farm of CRIJAF, Barrackpore, Kolkata during 2006 and 2007 with two irrigation regimes (IW/CPE ratio of 0.6 and 0.9) and three nutrient management schedules (100% N from ramie compost, 50% N from ramie compost + 50% N from chemical fertilizer and 100% N from chemical fertilizer based) to determine the effect of irrigation and nutrient management on growth, yield and water use of ramie. Irrigation based on 0.6 IW/CPE ratio recorded higher LAI (7.4-25%), net photosynthetic rate (4.6-9.3%), dry matter (28.5 - 42.8%), fibre yield (23 – 28%) and water use efficiency (7-19%) of ramie compared to 0.3 IW/CPE ratio irrigation treatment. In second year (2007), the LAI, net photosynthetic rate, fibre yield as well as water use efficiency of the crop receiving INM treatment (50% N from ramie compost + 50% N from inorganic source) was statistically at par to that receiving 100% N from chemical source. The results indicated that application of irrigation to ramie based on IW/CPE ratio of 0.6 and substitution of 50% of the recommended fertilizer nitrogen (15 kg/ha/cut) through integration of ramie compost in the fertilizer schedule of the crop showed better growth and fibre yield of ramie, increased the water use efficiency and economized the requirement of inorganic nitrogen by the crop and can be adopted for commercial cultivation of ramie in south Bengal condition.

Key words : Integrated nutrient management, LAI, Photosynthesis, Ramie, Irrigation, Water use efficiency and Yield

Ramie is a semi-perennial type important bastfibre crop which produces longest (120 mm) and strongest (40-65 g/tex) textile fibre of plant origin. Globally ramie is cultivated on 0.088 million ha area producing of 0.163 million tonnes fibres/annum with an average productivity of 1.86 tonnes/ha/annum (http://faostat.fao.org, 2011). In India, ramie is naturally distributed in the North-Eastern States like Asom, Arunachal Pradesh, Manipur, Mizoram, Nagaland but the area under the crop is meager. Traditionally, ramie is grown in these areas under rainfed condition. The erratic and scanty rainfall during the pre-monsoon and post-monsoon periods affects the fibre yield of the crop significantly and provision of irrigation during these periods is needed to increase the fibre yield of ramie particularly in non-traditional areas like south Bengal (Mitra and Sarkar 2005). Ramie, due to its high biomass production, removes significant quantity of nutrients from soil during its growth period. Hence adequate amount of nutrient needs to be added to ramie soil to maintain its health and sustain the productivity of the crop. The fibre is extracted mechanically and the fibre recovery in ramie under present mode of extraction is around 4-5% of the total biomass (fresh weight basis). Ramie fibre is highly cellulosic (85-90%) in nature, contains negligible amount of lignin (0.5%), decomposes easily and releases significant quantity of nutrients in soil. Thus, the huge quantity of ramie waste, if composted and added back to the soil in combinations with chemical fertilizers, can certainly reduce the requirement of chemical fertilizers, improve the soil health and also sustain the productivity of the crop in long run. Besides, it can also cut down the expenditure on fertilizer significantly. Keeping these views in mind, the present investigation was conducted to determine the effect of irrigation and integrated nutrient management on growth, fibre yield and water use of ramie in south Bengal condition.

MATERIALS AND METHODS

The experiment was conducted at Research Farm of CRIJAF at Barrackpore, Kolkata, West Bengal during 2006 and 2007. The experimental soil was sandy loam in texture with 0.6% organic carbon, and the values of available N, P and K were 240.5, 34.6 and 160 kg/ha, respectively. The mean bulk density of the soil (0 – 60 cm) was 1.42 Mg/m^3. The test genotype of ramie used was Kanai (R-67-34). The experiment was laid out in a split-plot design keeping two

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irrigation treatments (I_1: irrigation based on IW/CPE ratio of 0.3 and I_2: irrigation based on IW/CPE ratio of 0.6) in the main plots and three nutrient management treatments (F_1: 100% N from ramie compost, F_2: 50% N from ramie compost + 50% N from chemical fertilizer and F_3: 100% N from chemical fertilizer) in sub-plots. The depth of irrigation (IW) was 40 mm. The waste biomass generated during fibre extraction of ramie was composted and total N, P and K content of the compost was 1.5, 0.8 and 0.1%, respectively. During both the years of cultivation, nitrogen, phosphate and potash were added @ 30:15:15 kg/ha/cut. The ramie compost needed to supplement 50 and 100% of nitrogen were one and two tonnes/ha, repectively. The well decomposed ramie compost alone or with fertilizer was added to soil after each cutting. The ramie rhizomes were planted on 15th September 2005 and sprouting was observed from 15 days after planting. Gap filling was done subsequently in October month to develop uniform plant population. Due to lowering of temperature in subsequent winter months, the growth of ramie was uneven and stunted and stage back (cutting the stems at the base) operation was performed in end-February 2006 to ensure uniform growth of the crop. A general irrigation was applied to all the plots and subsequently irrigation and fertilizer were applied to the crop as per treatments. The soil samples were collected before and 24-48 hours after irrigation from different soil depths, oven dried at 105°C for 24 hr and the moisture content was determined thermo-gravimetrically. The consumptive water use (CU) by the crop was calculated as per Dastane (1972) and effective rainfall was calculated as per Dastane (1974). The leaf area index (LAI) and net photosynthesis of ramie were measured with LAI-2000 Plant Canopy Imager (LI-COR) and LI-6400 Portable Photosynthesis System (LI-COR), respectively. The measurements were taken from five plants in each plot on clear sunny days between 10.00 and 11.30 hr. The plant samples were collected from one meter row length randomly in each plot during each cutting and were oven dried at 60^{0}C for 24 hours and the dry weight was expressed in tonnes/ha. The crop was cut at the base at 55, 65, 55, 53 and 65 days interval in 2006 and at 56, 57, 56, 51, and 66 days interval in 2007, respectively for fibre yield. The fibre was extracted mechanically using 'Raspador Decorticator', washed in clean water, dried and fibre weight was expressed in tonnes/ha. The crop received 1647 and 1412 mm rainfall during 2006 and 2007, respectively.

RESULTS AND DISCUSSION

Leaf area index

The perusal of data revealed that during both the years of experimentation, the leaf area index (LAI) of ramie increased progressively up to 3rd cutting and declined thereafter in both the irrigation treatments. The LAI of the crop was found to be significantly higher in plots receiving I_2 irrigation treatment as compared to those receiving I_1 treatment in 1st, 2nd and 5th cuttings during both the years. This may be due to the better moisture condition in I_2 treatment as compared to I_1 as the former received an extra irrigation than the latter during these three cuttings. The higher rainfall during 3rd and 4th cutting might have nullified the effect of irrigation on LAI of ramie. Increased LAI due to irrigation was also reported in kenaf (Danalatos and Archantoulis 2010). During 2006, F_3 nutrient management treatment (100% nitrogen from inorganic source) recorded significantly higher LAI of ramie over F_1 (100% N from ramie compost) and F_2 (50% N from ramie compost + 50% N from chemical fertilizer) treatments in all the cuttings. In 2007, LAI of ramie crop receiving F_2 and F_3 treatments were statistically at par and both the treatments recorded significantly higher LAI over F_1 treatment throughout the growth period. The higher LAI in INM treatment (F_2) in the 2nd year might be attributed to the favourable effect of ramie compost in supply of nutrients for a longer period through mineralization of the added organic matter (Saha *et al.* 2008). Ramie compost alone possibly could not supplement the nutrient requirement of ramie thereby resulting into lower LAI value in F_1 treatment. Increase in LAI in sweet corn due to integrated nutrient management had been reported earlier by Efthimiadou *et al.* (2009).

Net photosynthetic rate

Maximum net photosynthetic rate (NPn) of ramie was observed during 2nd cut and it was less in 3rd and 5th cuts during both the years. The higher NPn of ramie during 2nd cutting might be attributed to favourable light and temperature conditions during this period while the comparatively lower light intensity during 3rd cut (coinciding with early monsoon months) or lower temperature particularly in night during 5th cut might have reduced the NPn values of the crop in both the years under study. The I_2 irrigation treatment recorded significantly higher NPn of ramie over I_1 irrigation treatment during both the years and maximum NPn value was recorded in 2nd cutting possibly due to improved moisture condition in this treatment (Fig 1). In general, I_2 irrigation treatment recorded 8.3, 4.0 and 4.6% higher NPn over I_1 treatment during 2006 and 9.3, 4.5 and 8.3% higher NPn over I_1 during 2007. Application of irrigation was found to influence photosynthesis significantly in maize crop also (Fazel and Lack 2011). In 2006, significant variation in NPn due to nutrient management was observed in ramie with maximum and minimum values recorded in F_3 (20.5 – 23.3 μmol/m^2/s) and F_1 (18.9 – 19.2 μmol/m^2/s) treatments, respectively. F_3 treatment recorded significantly higher NPn over F_2 in 2nd and 3rd cuttings. In the 5th cut in 2006 and in the subsequent cuts in the next year, no significant variation was observed in NPn of the crop receiving F_2 and F_3 treatments, though both the treatments recorded significantly higher NPn over F_1 treatment (Fig 1). The higher net photosynthetic rate of ramie in F_2 and F_3 nutrient treatments might be attributed to the increased LAI of the crop in these treatments that lead to increased CO_2 fixation by the crop canopy. The results confirm the

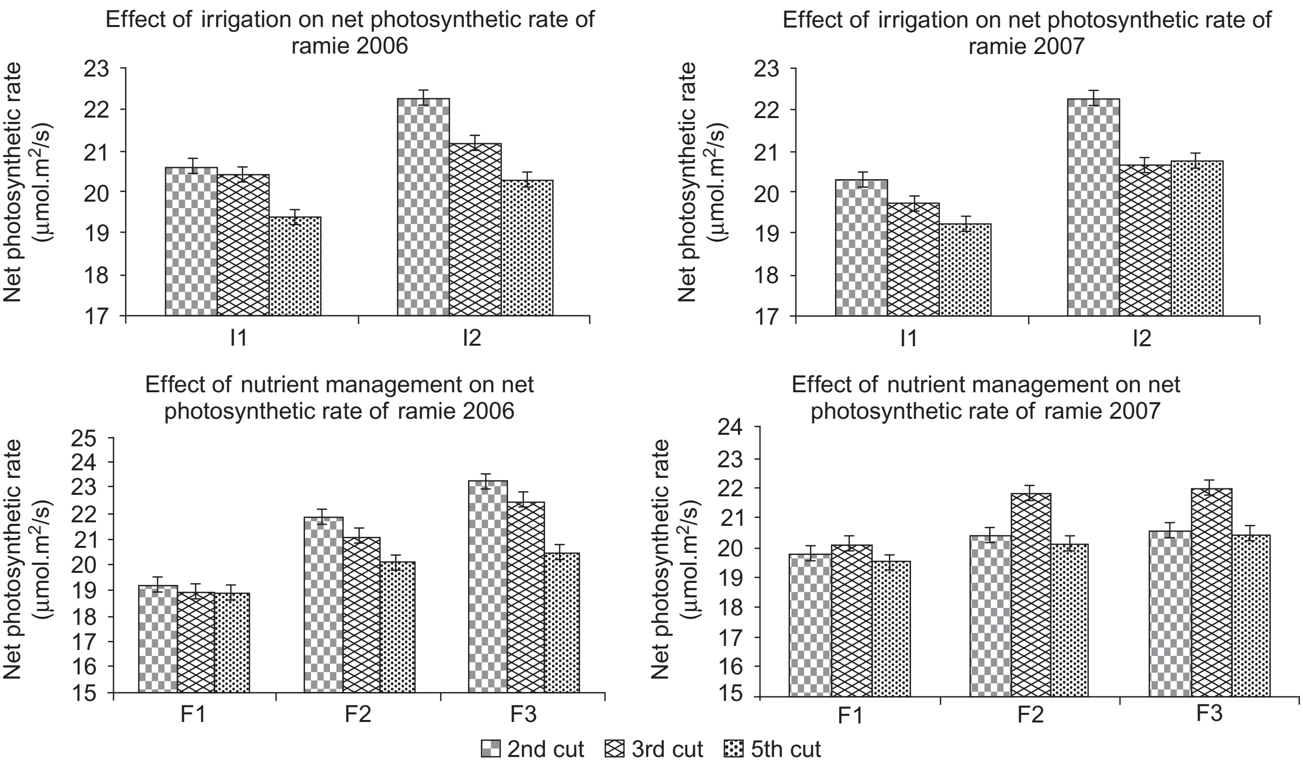

Fig 1 Effect of irrigation and nutrient management on net photosynthetic rate during crop growth period in 2006 and 2007

findings of Efthimiadou *et al.* (2009).

Dry matter accumulation

The dry matter of ramie increased significantly with increased irrigation frequency during the relatively dry period, i.e. in 1st, 2nd and 5th cuts during both the years. I_2 irrigation treatment recorded 30-30.5%, 28.5 – 30% and 32-42.8% higher dry biomass of the crop over I_1 treatment in 1st, 2nd and 5th cuts, respectively (Fig 2). The higher rainfall possibly had nullified the effects of irrigation on dry matter accumulation during 3rd and 4th cuttings. The increase in dry matter with irrigation was also reported in

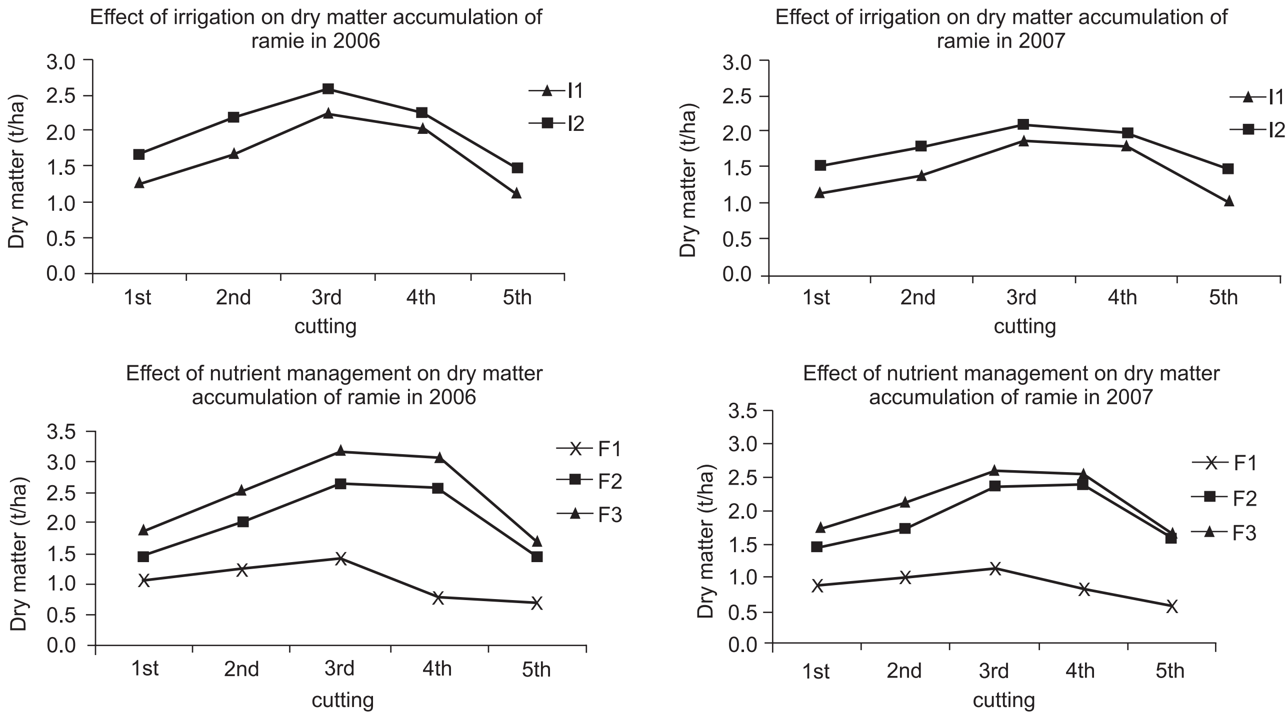

Fig 2 Effect of irrigation and nutrient management on dry matter accumulation during crop growth period in 2006 and 2007

roselle (El-Boraie *et al.* 2009). Application of 100% N from inorganic source (F_3) recorded significantly highest dry matter in ramie throughout the growth period in 2006 followed by F_2 and F_1 treatments. Similar trend was observed in the 1st and 2nd cuts in the subsequent year (2007) also. Interestingly from the 3rd cut onwards, F_2 and F_3 treatments were statistically at par but both the nutrient management treatments recorded significantly higher dry matter of the crop over F_1 treatment (Fig 2). The higher LAI and NPn of ramie in F_2 and F_3 treatments had lead to higher light interception and CO_2 fixation which might had increased the dry matter of the crop in these treatments. Similar increase in dry matter production in kenaf had been reported by Danalatos and Archantoulis (2010).

Fibre yield

Ramie crop receiving I_2 irrigation treatment recorded significantly higher fibre yield as compared to I_1 treatment in 1st, 2nd and 5th cuttings during both the years (2006 and 2007) and also when the data was pooled (Table 1). Fibre yield did not vary significantly between I_1 and I_2 irrigation treatments during the 3rd and 4th cuttings possibly due to excessive rainfall which had nullified the effect of irrigation. The average increase in fibre yield of ramie due to irrigation was around 26–28% during pre-monsoon and about 23% during post monsoon period (pooled data) and the magnitude of increase was more in 2006 (Table 1). The crop receiving I_2 irrigation treatment enjoyed favourable soil moisture condition, developed better canopy, intercepted more light resulting to increased photosynthesis which finally lead to higher biomass and fibre yield of the crop as compared to I_1 irrigation treatment. Similar increase in economic yield of roselle due to increased irrigation frequency had been reported by El-Boraie *et al.* (2009). In the early growth stage (1st, 2nd and 3rd cuts of 2006), fibre yield of ramie varied significantly among the nutrient management treatments and was in the order $F_3 > F_2 > F_1$. Subsequently no significant variation was observed in the fibre yield of the crop receiving F_2 and F_3 treatments while both the treatments recorded significantly higher fibre yield of ramie over F_1 treatment (Table 1). Similar trend was observed in total annual yield of the crop and also when the yield data was pooled. The combined effect of increased LAI, NPn and dry matter accumulation in these two treatments (100% N from chemical source and the INM treatment) might have finally translated into enhanced fibre yield of the crop. The low fibre yield of ramie in F_1 treatment (100% N from ramie compost) might be attributed to the fact that ramie compost alone could not satisfy the nutrient requirement of the crop which otherwise is a heavy feeder, and resulted into poor growth and yield. The experimental findings further revealed that 50% of the inorganic nitrogen could be effectively substituted through integration of ramie compost in the fertilizer schedule and the fibre yield of ramie could be sustained. Increase in fibre yield due to conjunctive use of organics with inorganic fertilizer had been reported in jute (Mitra *et al.* 2010).

Table 1 Effect of irrigation and nutrient management on fibre yield of ramie

Treatment	Fibre yield (tonnes/ha) of ramie																	
	1st cut			2nd cut			3rd cut			4th cut			5th cut			Total annual yield		
	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean
Irrigation																		
I_1 IW/CPE = 0.3	0.25	0.24	0.25	0.32	0.29	0.31	0.42	0.41	0.41	0.42	0.36	0.39	0.22	0.21	0.22	1.63	1.51	1.57
I_2 IW/CPE = 0.6	0.34	0.29	0.32	0.42	0.36	0.39	0.48	0.42	0.45	0.45	0.37	0.41	0.27	0.28	0.27	1.96	1.72	1.84
SEm±	0.005	0.005	0.005	0.016	0.006	0.010	0.001	0.005	0.006	0.002	0.007	0.003	0.008	0.015	0.012	0.046	0.029	0.056
CD(P=0.05)	0.03	0.03	0.02	0.10	0.04	0.04	NS	NS	NS	NS	NS	NS	0.05	0.09	0.05	0.28	0.18	0.22
Fertilizer																		
F_1 100% N from ramie compost	0.22	0.15	0.19	0.22	0.14	0.18	0.24	0.16	0.19	0.13	0.15	0.14	0.12	0.12	0.12	0.93	0.72	0.83
F_2 50% N from ramie compost + 50% N from chemical fertilizer	0.31	0.31	0.31	0.40	0.42	0.41	0.51	0.53	0.52	0.58	0.46	0.52	0.29	0.30	0.29	2.09	2.02	2.06
F_3 100% N from chemical fertilizer	0.35	0.34	0.35	0.48	0.43	0.46	0.61	0.55	0.58	0.59	0.48	0.54	0.32	0.32	0.32	2.35	2.12	2.24
SEm±	0.006	0.009	0.006	0.027	0.006	0.020	0.027	0.012	0.020	0.015	0.009	0.010	0.012	0.015	0.010	0.082	0.036	0.060
CD(P=0.05)	0.02	0.03	0.02	0.09	0.02	0.06	0.09	0.04	0.07	0.05	0.03	0.03	0.04	0.05	0.04	0.27	0.12	0.19

Table 2 Effect of irrigation and nutrient management on consumptive water use of ramie

Treatment	Consumptive water use (mm) of ramie																	
	1st cut			2nd cut			3rd cut			4th cut			5th cut			Total		
	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean
Irrigation																		
I_1 IW/CPE = 0.3	111.7	90.7	103.2	227.0	135.8	181.4	241.0	215.0	228.0	248.0	225.7	236.9	127.0	97.6	112.3	954.7	764.8	859.8
I_2 IW/CPE = 0.6	145.7	112.0	128.9	248.3	139.6	193.9	244.0	219.0	231.5	253.0	230.0	241.5	144.0	121.7	132.9	1035.0	822.3	928.7
SEm±	2.34	1.87	2.29	3.82	2.28	3.43	4.34	3.98	4.15	4.45	4.13	4.2	2.23	1.79	2.22	14.50	12.49	15.05
CD(P=0.05)	8.5	6.8	7.2	13.9	8.3	10.8	NS	NS	NS	NS	NS	NS	8.1	6.5	7.0	52.7	45.4	47.4
Fertilizer																		
F_1 100% N from ramie compost	110.0	73.3	91.7	210.0	108.4	159.2	223.0	128.0	175.5	165.0	123.5	144.3	127.0	108.3	117.7	835.0	541.5	688.3
F_2 50% N from ramie compost + 50% N from chemical fertilizer	134.0	110.5	122.3	249.0	145.9	197.5	249.0	258.0	253.5	250.0	277.0	263.5	136.0	118.5	127.3	1018.0	909.9	964.0
F_3 100% N from chemical fertilizer	143.0	120.1	131.6	255.0	158.8	206.9	257.0	266.0	261.5	266.0	283.0	274.5	144.0	142.1	143.1	1065.0	970.0	1017.5
SEm±	2.17	1.73	1.96	3.69	2.20	3.11	4.14	3.56	4.02	4.20	3.86	4.13	1.97	1.73	1.92	14.41	12.00	13.61
CD(P=0.05)	6.4	5.1	5.6	10.9	6.5	8.9	12.2	10.5	11.5	12.4	11.4	11.8	5.8	5.1	5.5	42.5	35.4	38.9

Table 3 Effect of irrigation and nutrient management on water use efficiency of ramie

Treatment	Water use efficiency (kg/ha/mm) of ramie																
	1st cut			2nd cut			3rd cut			4th cut			5th cut			Annual mean	
	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean	2006	2007
Irrigation																	
I_1 IW/CPE = 0.3	2.09	2.61	2.33	1.41	2.16	1.69	1.75	1.89	1.82	1.70	1.58	1.64	1.75	2.16	1.93	1.71	1.97
I_2 IW/CPE = 0.6	2.33	2.62	2.45	1.69	2.58	2.01	1.98	1.93	1.96	1.77	1.63	1.70	1.84	2.32	2.05	1.89	2.10
SEm±	0.038	0.043	0.042	0.026	0.036	0.035	0.025	0.028	0.028	0.032	0.029	0.03	0.025	0.030	0.030	0.025	0.028
CD(P=0.05)	0.11	0.13	0.12	0.08	0.13	0.11	NS	NS	NS	NS	NS	NS	0.09	0.11	0.1	0.09	0.1
Fertilizer																	
F_1 100% N from ramie compost	1.99	1.98	1.99	1.06	1.28	1.13	1.06	1.23	1.12	0.81	1.21	0.98	0.97	1.09	1.03	1.12	1.99
F_2 50% N from ramie compost + 50% N from chemical fertilizer	2.31	2.81	2.61	1.62	2.84	2.08	2.06	2.06	2.06	2.32	1.68	1.98	2.13	2.55	2.33	2.06	2.31
F_3 100% N from chemical fertilizer	2.43	2.81	2.59	1.89	2.68	2.20	2.37	2.08	2.22	2.21	1.71	1.96	2.20	2.24	2.22	2.20	2.43
SEm±	0.038	0.043	0.042	0.021	0.034	0.031	0.024	0.020	0.024	0.030	0.026	0.029	0.024	0.027	0.027	0.024	0.038
CD(P=0.05)	0.11	0.13	0.12	0.08	0.10	0.09	0.07	0.06	0.07	0.09	0.08	0.08	0.07	0.08	0.08	0.07	0.11

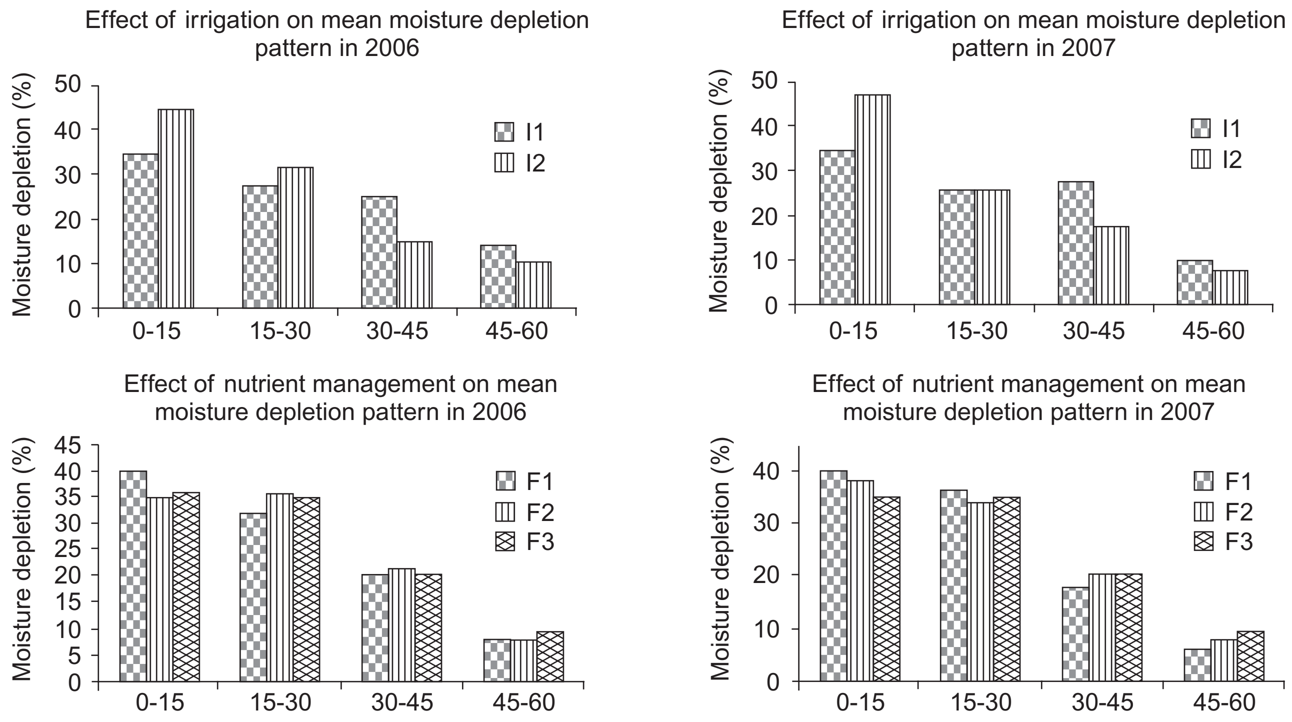

Fig 3 Effect of irrigation and nutrient management on mean moisture depletion pattern during crop growth period in 2006 and 2007

Water use

The crop consumed 80.3 and 57.5 mm more water during 2006 and 2007, respectively under higher irrigation frequency (0.6 IW/CPE ratio) (Table 2). Here also, the ramie plants receiving I_2 irrigation treatment consumed significantly more water compared to those receiving I_1 treatment in 1st, 2nd and 5th cuttings. Similar trend was observed in annual consumptive water use of the crop.The data on layer wise moisture depletion pattern revealed that at increased irrigation level (I_2), the crop extracted more moisture from the top soil layers (0-15 and 15-30 cm layers in 2006 and 0-15 cm in 2007) and reverse was true in I_1 treatment (Fig 3). This might be attributed to the fact that the roots of ramie were concentrated at the top layers (data not presented) in I_2 treatment due to adequate water in top soil while in I_1 treatment the roots penetrated deeper in the soil in search of water and more moisture was extracted from lower layers. Increased water use by *Bt* cotton at higher irrigation frequency had also been reported by Ahlawat and Gangaiah (2010). Significantly higher water use efficiency (WUE) of ramie was recorded in I_2 treatment compared to I_1 during both the years during the pre-monsoon and post monsoon periods which may be due to relatively higher fibre yield of the crop (Table 3). Scheduling irrigation at 80% of soil water depletion increased the WUE in cotton (Hussein *et al*. 2010). During both the years under study, the ramie crop receiving F_2 and F_3 treatments consumed significantly more water than the crop under F_1 (100% N from ramie compost) treatment. The low water use by ramie under F_1 treatment may be possibly due to poor crop growth (Table 2). The profile moisture depletion pattern also revealed that more moisture was extracted from the deeper soil layers in F_2 and F_3 treatments as compared to F_1 where extraction was more in 0-15 cm layer during both the years (Fig 3). This might be due to the fact that enhanced nutrient availability in F_2 and F_3 treatments have promoted root growth and consequently more moisture was extracted from deeper layers of the soil. The ramie crop receiving F_2 and F_3 treatments recorded significantly higher water use efficiency (WUE) than that with F_1 treatment during both the years while there was no perceptible variation in WUE of the crop between F_2 and F_3 treatments (Table 3). On an average, the WUE of ramie was 69-84% more in F_2 and F_3 treatments compared to F_1 treatment. The lower water use efficiency of ramie under sole ramie compost treatment was primarily due to poor fibre yield of the crop. Increase in water use efficiency with increased nitrogen application had also been reported in *Bt* cotton (Bandyopadhyay *et al*. 2009).

The results of the present investigation clearly indicated that irrigation may be scheduled to ramie based on IW/CPE ratio of 0.6 as it resulted in higher growth, fibre yield and water use efficiency of the crop. Half of the recommended fertilizer nitrogen (15 kg/ha/cut) can be supplemented through integration of ramie compost in fertilizer schedule of ramie as it effectively sustained the growth and fibre yield of the crop, increased the water use efficiency and economized the requirement of inorganic nitrogen.

REFERENCES

Ahlawat I P S and Gangaiah B. 2010. Response of *Bt* cotton (*Gossypium hirsutum*) hybrids to irrigation. *Indian Journal of Agricultural Sciences* **80** (4): 271–4.

Bandyopadhyay K K, Prakash A H, Sankaranarayanan K, Dharajothi B and Gopalakrishnan N. 2009. Effect of irrigation and nitrogen on soil water dynamics, productivity and input-use efficiency of *Bt* cotton (*Gossypium hirsutum*) in a Vertic Ustropept. *Indian Journal of Agricultural Sciences* **79** (6) : 448–53.

Danalatos N G and Archantoulis S V. 2010. Growth and bionmass productivity of kenaf (*Hibiscus cannabinus* L.) under different inputs and agricultural management practices in central Greece. *Industrial Crops and Products* **32**: 231–40.

Dastane N G. 1972. Practical Manual for Water Use Research in Agriculture. Navbharat Prakashan, Poona, Maharastra, p 120.

Dastane N G. 1974. Effective rainfall in irrigated agriculture. Irrigation and Drainage Paper 25, FAO, Rome, Italy.

Efthimiadou Aspasia, Bilalis Dimitrios, Karkanis Anestis, Froud-Williams Bob and Eleftherochorinos Ilias. 2009. Effect of cultural system (organic and conventional) on growth, photosynthesis and yield components of sweet corn (*Zea mays* L.) under semi-arid environment. *Notulae Botanicae Horti Agrobotanici* **37** (2): 104–11.

El-Boraie F M, Gaber A M and Abdel-Rahman G. 2009. Optimizing irrigation schedule to maximize water use efficiency of *Hibiscus sabdariffa* under Shalatien conditions. *World Journal of Agricultural Sciences* **5**(4): 504–14.

Fazel M Alavi and Lack S H. 2011. The effects of irrigation-off at different growth stages, planting patterns and plant population on grain yield and dry matter remobilization on grain corn (*Zea mays* L.). *World Applied Sciences Journal* **15** (4): 463–73.

Hussein Faud, Janat Mussaddak and Yakoub Abdallah. 2011. Assessment of yield and water use efficiency of drip-irrigated cotton (*Gossypium hirsutum* L.) as affected by deficit irrigation. *Turkish Journal of Agriculture and Forestry* **35**: 611–21.

Mitra S, Roy A, Saha A R, Maitra D N, Sinha M K, Mahapatra B S and Saha S. 2010. Effect of integrated nutrient management on fibre yield, nutrient uptake and soil fertility in jute (*Corchorus olitorius*). *Indian Journal of Agricultural Sciences* **80** (9): 801–4.

Saha A R, Maitra D N, Majumdar B, Saha S and Mitra S. 2008. Effect of integrated nutrient management on roselle (*Hibiscus sabdariffa*) productivity, its mineral nutrition and soil properties. *Indian Journal of Agricultural Sciences* **78** (5): 418–21.