Int.J.Curr.Microbiol.App.Sci (2018) *7*(10): 2101-2108

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 10 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.710.242

Application of Micro-Irrigation and Micro-Nutrients to Improve Fibre Yield and Water Use Efficiency in Sisal (*Agave sisalana* Perr. Ex Engelm.)

D.K. Kundu[1*], S. Sarkar[1], A.R. Saha[1], A.K. Jha[2] and M.S. Behera[1]

[1]*Crop Production Division, ICAR-Central Research Institute for Jute and Allied Fibres, Nilgunj, Barrackpore, Kolkata-700120, India*
[2]*Sisal Research Station, ICAR-CRIJAF, Bamra, Sambalpur, Odisha, India*

**Corresponding author*

Keywords

Sisal, *Agave sisalana*, Micro-irrigation, Micro-nutrient, Yield, Water use efficiency

Article Info

Accepted:
15 September 2018
Available Online:
10 October 2018

ABSTRACT

Field experiment was conducted during 2011-2015 at Sisal Research Station (22.041°N, 84.295°E, 267 m above mean sea level, AMSL), Bamra, Odisha, India to study the effect of drip-irrigation and micronutrients (Zn and B) on growth, fibre yield, water use efficiency, nutrient and micronutrient content in sisal (*Agave sisalana* Perr. Ex Engelm.). It was observed that interaction of drip-irrigation @ 4 l/hr for 2 hrs at 2 weeks interval during 14-23 standard meteorological week (SMW) x micronutrients (zinc sulphate @ 20 kg + borax 15 kg/ha) produced the longest leaf (97.2.cm) and produced the maximum number of leaves (139.87 x 10^3) in sisal. The maximum fibre yield was recorded either with drip-irrigation @ 4 l/ha for 4 hrs at 2 weeks interval during 14-23 SMW together with zinc sulphate 20 kg/ha + borax 15 kg/ha (1546 kg/ha), or with drip-irrigation @ 4 l/hr for 2 hrs at 2 weeks interval during 14-23 SMW together with zinc sulphate 20 kg/ha + borax 15 kg/ha (1493 kg/ha). Application of micronutrients (zinc sulphate 20 kg + borax 15 kg/ha) together with drip-irrigation (4 l/hr for 2 hours at 2 weeks interval during 14-23 SMW) gave the highest water use efficiency (4.52 kg/ha-mm). Water use efficiency reduced if the drip-irrigation (4 l/hr at 2 weeks interval during 14-23 SMW) was prolonged for 4 hours (3.46 kg/ha-mm). The highest Zn content (19.3 ppm) was recorded in treatments where zinc sulphate (@ 20 kg/ha) together with borax (@ 15 kg/ha) was applied to soil. Similarly the highest B content (14.4 ppm) was also observed in zinc sulphate (@ 20 kg/ha) + borax (@ 15 kg/ha) applied cases.

Introduction

The important xerophytic plant of Asparagaceae family is sisal (*Agave* sp) from which commercial hard fibre is produced from its long leaf. Several species of Agaves are cultivated, among which *A. sisalana*, *A. cantala*, *A. vera-cruz*, *A. amaniensis*, *A. angustifolia*, *A. fourcryodes* are commercially important (Sarkar and Jha, 2017). However, *A. sisalana* contributes nearly 80-85% of the total sisal fibre production of the World. Western Odisha, Jharkhand, Chhattisgarh, and areas of Maharashtra, Andhra Pradesh and Karnataka are the important sisal growing zones of India. India's sisal fibre productivity is only 600-700 kg/ha due to age old cultivation practices and other concerned reasons. Considerable amount of sisal fibre is imported by India from Brazil, Tanzania, Madagascar and other sisal growing countries as the native total production is not sufficient to meet the country's internal need (Sarkar, 2015). So, it is necessary to increase productivity and total production of sisal fibre in India. It is known that sisal can thrive without irrigation as evidenced by the higher concentration biochemical indicator of drought such as proline (4.26 µg/g) when exposed to drought stress (Riaz *et al.*, 2016); but it was also found in some field trial that sisal responds well to irrigation and increased fibre yield was obtained in India (Saha, 2001). The water requirement of sisal (WR ≈ ETc or Crop evapotranspiration under standard condition) was estimated to be 550-800 mm considering Kc (Crop coefficient 0.4-0.7, depending upon plant density and water management) and maximum crop height of 1.5 m (Anonymous 1992; Anonymous, 2002). During 14-22 standard meteorological week (SMW; 2 April to 3 June) the total rainfall in western Odisha is only 38.57 mm from 2.5 rainy days and in 23rd SMW the rainfall is 39.89 mm for 2 rainy days due to initiation of monsoon (Sarkar *et al.*, 2013). Although the Kc value for sisal (0.4-0.7) is quite low as compared to other important fibre crops such as cotton (Kc 1.15-1.20) and flax (Kc 1.10), but during this dry spell (14-23 SMW) drip-irrigation might be beneficial for sisal. The soils of most of the sisal growing tracts of central plateau zone of India are acidic in reaction and deficient in micronutrients such as Zn and B. Moreover, Pinkerton (1971) reported that deficiency of Zn and B (together with some other micronutrients) affected leaf length, rate of unfurling of leaf and leaf elongation rate which ultimately affected fibre yield and quality of sisal fibre in Kenya. But such work on micronutrients has not so far been conducted for Indian sisal producing areas. In view of the scanty information on these aspects (micro-irrigation and micronutrients) of sisal crop management in India, field experiment was conducted at Sisal Research Station, Bamra, Odisha to study the effect of drip-irrigation and micronutrients (Zn and B) on the fibre yield, and water use efficiency in sisal.

Materials and Methods

A field experiment was conducted during 2011-2015 at the Sisal Research Station (located at 22.041°N, 84.295°E, 267 m AMSL) a regional research station of ICAR-CRIJAF, at Bamra, in Sambalpur district of Odisha, India to study the effect of drip-irrigation, and micronutrients (Zn & B) on fibre yield, and water use efficiency in sisal. Soil at the experimental site belongs to typicochraqualf and was acidic in reaction with pH (1:2.5 w/v) in water 5.1, low in organic carbon 4.4 g/kg, having available N 226 kg/ha, available P 4.9 kg/ha and available K 168 kg/ha. The experiment was laid in 2 factor split plot design with 3 levels of irrigation (I_1= no irrigation; I_2: drip irrigation with discharge rate of 4 l/hr for 2 hours at 2 weeks intervalduring 14-23 SMW; I_3: drip irrigation with discharge rate of 4 l/hr for 4 hours at 2 weeks intervalduring 14-23 SMW) in main plot and 4 levels of micronutrients [M_1= no micronutrient;M_2=Zn as zinc sulphate @ 20 kg/ha in soil;M_3= B as borax @ 15 kg/ha in soil; and M_4= Zn as zinc sulphate @ 20 kg/ha + B as borax @ 15 kg/ha in soil] in sub plots with individual plot size of 10 m x 3 m replicated thrice. Irrigation treatment was applied through drip method and the drip system was installed in the experimental plot with one nozzle near the base of each sisal plant so that irrigated water could be applied to the plants efficiently and economically. Healthy suckers of sisal were planted in the recommended double row planting system [(1m x 1m) x 3 m] in the month of July, 2011. Other standard recommended agronomic practices were followed to raise the experimental sisal plantation. Leaves were harvested from the plants after 2½ years of planting. Leaf harvesting continued for consecutive 2 years in the winter season (December-January) of 2013-14 and 2014-15. The harvested leaves were carried to the extraction site and fibres were extracted with diesel operated sisal decorticator machine of 5 HP capacity. The biometric field data of crop and laboratory data of plant and soil samples were processed and analysed by statistical software IBM SPSS Statistics v. 24.

Results and Discussion

Effect of drip-irrigation and micronutrients on leaf length of sisal at harvest

Irrespective of micronutrient levels, drip-irrigation at a discharge rate of 4 l/hr for 4 hrs at 2 weeks interval (I_4) produced the longest leaves (90.0 cm), followed by the leaf length (86.9 cm) obtained with I_3 (drip-irrigation @ 4 l/hr for 4 hrs at 2 weeks interval (Table 1). Irrespective of irrigation levels, Zn (zinc sulphate 20 kg/ha) together with B (borax 15 kg/ha) produced the longest leaves (90.6 cm). In interaction mode, I_3 (drip-irrigation @ 4 l/hr for 2 hrs at 2 weeks interval) x M_4 (zinc sulphate @ 20 kg + borax 15 kg/ha) produced the longest leaf of sisal (97.2.cm). It is well established that longer leaves of sisal directly contribute to the higher fibre yield in sisal (Sarkar *et al.,* 2017). Nobel *et al.,* (1988) reported that application of B @ 10 kg/ha (together with N, P, K) enhanced growth of Agave in California.

Effect of drip-irrigation and micronutrients on number of harvested leaves

Either I_2 (drip-irrigation @ 4 l/hr for 2 hrs at 2 weeks interval) or I_3 (drip-irrigation @ 4 l/ha for 4 hrs at 2 weeks interval) singly, produced the maximum number of harvestable leaves 134.27 x 10^3 and 138.43 x 10^3, respectively (Table 2). Irrespective of irrigation levels, application of 20 kg zinc sulphate + 15 kg borax produced the maximum number of leaves (139.51 x 10^3). Interaction effect of I_2 (drip-irrigation @ 4 l/hr for 2 hrs at 2 weeks interval) x M_3 (borax @ 15 kg/ha) produced the maximum number of leaves (139.87 x 10^3). Similar result of more harvested leaves due to micro-irrigation was also reported earlier (Kundu *et al.,* 2013). More number of harvested leaves resulted higher fibre yield of sisal (Sarkar *et al.,* 2017).

Effect of drip-irrigation and micronutrients on total weight of harvested leaves

Irrespective of micronutrient levels, I_2 (drip-irrigation @ 4 l/hr for 2 hrs at 2 weeks interval) and I_3 (drip-irrigation @ 4 l/ha for 4 hrs at 2 weeks interval) produced the maximum weight of harvested leaves of 31.75 and 34.15 t/ha, respectively (Table 3). While comparing different levels of micronutrients alone, it was recorded that the M_4 (zinc sulphate @ 20 kg + borax @ 15 kg/ha) produced the highest harvested leaf weight (34.57 t/ha). In interaction, I_2 (drip irrigation @ 4 l/ha for 2 weeks at 2 weeks interval) x M_4 (zinc sulphate @ 20 kg and borax @ 15 kg/ha) and I_3 (drip-irrigation @ 4 l/ha for 2 weeks interval) x M_4 gave the highest weight of harvested leaves of 37.33 and 38.31 t/ha, respectively.

Effect of drip-irrigation and micronutrients on fibre yield of sisal

Fibre yield of sisal differed significantly due to application of drip-irrigation and micronutrients individually or in combination (Table 4). Irrespective of micronutrient levels, drip-irrigation @ 4 l/ha for 4 hrs at 2 weeks interval (I_3) and drip-irrigation @ 4 l/hr for 2 hrs at 2 weeks interval (I_2) produced the highest fibre yield of 1393 and 1293 kg/ha, respectively. Whereas, application of zinc sulphate (20 kg/ha) together with borax (15 kg/ha) produced the highest fibre yield of 1382 kg/ha. In interaction mode, the highest fibre yield was recorded either with drip-irrigation @ 4 l/ha for 4 hrs at 2 weeks interval together with zinc sulphate 20 kg/ha + borax 15 kg/ha (1546 kg/ha), or with drip-irrigation @ 4 l/hr for 2 hrs at 2 weeks interval together with zinc sulphate 20 kg/ha + borax 15 kg/ha (1493 kg/ha). The lowest fibre yield was recorded with no-irrigation and no micronutrient applied cases (786 kg/ha).

It was found that drip-irrigation (@ 4 l/ha for 4 hrs at 2 weeks interval) together with zinc sulphate 20 kg + borax 15 kg/ha gave 1.97 times and drip-irrigation (@ 4 l/hr for 2 hrs at 2 weeks interval) together with zinc sulphate 20 kg + borax 15 kg/ha gave 1.90 times fibre yield in sisal as compared to no-irrigation and no micronutrient application. Application of drip-irrigation alone increased the fibre yield by 49.9% and application of micronutrients (zinc sulphate 20 kg + borax 15 kg/ha) alone couldincrease the fibre yield by 31.2% in sisal.Earlier in Israel, the highest fibre yield of sisal (978 kg/ha from 2222 plants) was obtained with 252 mm irrigation (in addition to 200 mm rainfall) applied in 2 irrigations (Shalhevet *et al.*, 1979). In recent past it was reported that *Agave americana* crop reached 9.3 Mg dry mass/ha/year with 530 mm of annual water inputs, including both rainfall and irrigation (Davis *et al.*, 2017). Besides yield increase by drip-irrigation, it was reported that drip-irrigation (@ 4 l/hr for 2 hrs at 2 weeks interval) alone could produce higher number of suckers (76.14 x 10^3) within 6 years, which is about 32.8% more as compared to no-irrigation (Sarkar *et al.*, 2018).

Table.1 Effect of drip-irrigation and micronutrients on leaf length of sisal at harvest

Drip irrigation	Leaf length (cm)				
	Levels of micronutrients				
	M_1	M_2	M_3	M_4	**Mean**
I_1	73.9	76.6	77.6	80.7	**77.2**
I_2	82.3	85.1	86.4	93.9	**86.9**
I_3	83.8	88.7	90.4	97.2	**90.0**
Mean	**80.0**	**83.5**	**84.8**	**90.6**	
CD (5%)	I = 2.5; M = 4.1; I x M = 2.2				

Table.2 Effect of drip-irrigation and micronutrients on number of harvested leaves

Drip irrigation	Number of leaves harvested (in thousand)				
	Levels of micronutrients				
	M_1	M_2	M_3	M_4	**Mean**
I_1	112.80	120.13	124.40	126.00	**120.83**
I_2	128.00	132.27	132.80	144.00	**134.27**
I_3	129.47	135.87	139.87	128.53	**138.43**
Mean	**123.42**	**129.42**	**132.35**	**139.51**	
CD (5%)	I = 4.90; M = 2.61; I x M = 4.96				

Table.3 Effect of drip-irrigation and micronutrients on total weight of harvested leaves

Drip irrigation	Weight of harvested leaves (t/ha)				
	Levels of micronutrients				
	M_1	M_2	M_3	M_4	Mean
I_1	20.91	23.33	25.04	28.07	24.34
I_2	28.38	30.12	31.15	37.33	31.75
I_3	28.73	34.00	35.55	38.31	34.15
Mean	26.01	29.15	30.58	34.57	
CD (5%)	I = 3.72; M = 2.65; I x M = 3.55				

Table.4 Effect of drip-irrigation and micronutrients on fibre yield of sisal

Drip irrigation	Fibre yield (kg/ha)				
	Levels of micronutrients				
	M_1	M_2	M_3	M_4	Mean
I_1	786	880	946	1106	929
I_2	1173	1226	1280	1493	1293
I_3	1200	1400	1426	1546	1393
Mean	1053	1169	1217	1382	
CD (5%)	I = 105; M = 99; I x M = 77				

Table.5 Effect of drip-irrigation and micronutrients on water use efficiency of sisal

Irrigation levels	Water use efficiency (kg fibre/ha-mm water)				
	Levels of micronutrients				
	M_1	M_2	M_3	M_4	Mean
I_1 (CU= 258.5 mm)	3.04	3.40	3.66	4.28	3.60
I_2 (CU= 330.6 mm)	3.55	3.71	3.87	4.52	3.91
I_3 (CU= 402.6 mm)	2.98	3.48	3.54	3.84	3.46
Mean (CU= 330.6 mm)	3.18	3.53	3.68	4.18	

CU = Consumptive use of water

Table.6 Effect of drip-irrigation and micronutrients on major nutrient content in leaves

Irrigation	N (%)				P (%)				K (%)			
	Levels of micronutrients											
	M_1	M_2	M_3	M_4	M_1	M_2	M_3	M_4	M_1	M_2	M_3	M_4
I_1	0.97	0.99	1.00	1.08	0.108	0.120	0.124	0.128	0.554	1.012	1.676	1.188
I_2	1.10	1.25	1.23	1.26	0.135	0.140	0.169	0.168	0.650	1.164	1.760	1.518
I_3	1.21	1.32	1.30	1.35	0.137	0.182	0.185	0.209	1.210	1.650	1.914	1.672

Table.7 Effect of drip-irrigation and micronutrients on Zn and B content in sisal leaves

Irrigation	Zn (ppm)				B (ppm)			
	Levels of micronutrients							
	M_1	M_2	M_3	M_4	M_1	M_2	M_3	M_4
I_1	2.0	14.8	2.3	17.0	3.7	4.1	12.9	13.5
I_2	2.1	15.5	2.7	19.2	4.0	4.4	13.8	14.2
I_3	2.1	16.2	2.8	19.3	4.2	4.6	14.2	14.4

Effect of drip-irrigation and micronutrients on water use efficiency in sisal

Irrespective of micronutrients levels, application of drip-irrigation @ 4 l/hr for 2 hrs at 2 weeks interval resulted the highest water use efficiency in sisal (3.91 kg/ha-mm) (Table 5). The value of water use efficiency reduced if the drip-irrigation (4 l/hr at 2 weeks interval) was prolonged for 4 hours (3.46 kg/ha-mm). Davis *et al.,* (2017) reported that water use efficiency in sisal declined in treatments with greatest water input (780 mm/year). Application of micronutrients (zinc sulphate 20 kg + borax 15 kg/ha) together with drip-irrigation (4 l/hr for 2 hrs at 2 weeks interval) gave the highest water use efficiency (4.52 kg/ha-mm).

It was recorded that incorporation of micronutrients (zinc sulphate 20 kg + borax 15 kg/ha) in drip-irrigation treatment (4 l/hr for 2 hours at 2 weeks interval) could improve the water use efficiency by 15.6% in sisal. In Israel, the water use efficiency in sisal obtained was 3.55, 3.22 and 1.07 kg fibre/ha-mm from one, two and eight irrigations, respectively (Shalhevet *et al.*, 1979). Earlier Mekonnen and Hoekstra (2011) reported that the blue water footprint (volume of surface and ground water consumed for production of crop) for sisal fibre is only 9 m^3/t, which is considerably less than the blue water footprint for jute (33 m^3/t), ramie (201 m3/t) and flax fibre (443 m^3/t). FAO also opined that sisal requires relatively small amount of water and excess water will negatively affect yield (Anonymous, 1992).

Effect of drip-irrigation and micronutrients on major nutrient content in sisal leaves

The highest nitrogen (N) content was recorded in drip-irrigation (@ 4 l/hr for 4 hrs at 2 weeks interval) and micronutrients (zinc sulphate 20 kg + borax 15 kg/ha) applied plots (1.35 % N) (Table 6). Similarly, the highest phosphorus (P) content in leaf was obtained in drip-irrigation (@ 4 l/hr for 4 hrs at 2 weeks interval) and micronutrients (zinc sulphate 20 kg + borax 15 kg/ha) treatments (0.209% P). However, the maximum potassium (K) content was recorded in drip-irrigation (@ 4 l/hr for 4 hrs at 2 weeks interval) and borax (15 kg/ha) applied cases (1.914% K). Drip-irrigation alone could increase the leaf N content by 16.4%, P content by 50% and K content by 45% in sisal as compared to no-irrigation treatment.

Effect of drip-irrigation and micronutrients on Zn and B content in sisal leaves

Drip-irrigation has not exerted any significant effect on micronutrient content (Zn & B) in sisal leaves. It was observed that soil application of Zn as zinc sulphate (@ 20 kg/ha) increased the Zn content and application of B as borax (@ 15 kg/ha) in soil enhanced the B content in sisal leaves (Table 7). The highest Zn content (19.3 ppm) was recorded in treatments where zinc sulphate (@ 20 kg/ha) together with borax (@ 15 kg/ha) was applied in soil. Similarly the highest B content (14.4 ppm) was also observed in zinc sulphate (@ 20 kg/ha) + with borax (@ 15 kg/ha) applied cases. Similar observations of Zn and B (together with other micronutrients viz. Mn, Cu, Fe and Mo) were recorded in Kenyan soil in sisal cultivation (Pinkerton, 1971). It was interesting to note that the Zn concentration was lower in cases where B was not applied. Deficiency of B decreased Zn concentration by 12.94 to 19.27% in sisal leaves. Similar report Pinkerton (1971) mentioned that deficiency of boron (and copper) depressed Zn uptake by sisal in Kenya.

From the field experiment it may be concluded that application of drip-irrigation @ 4 l/hr for 2 hrs at 2 weeks interval during 14-23 SMW) together with micronutrients (zinc sulphate @ 20 kg + borax 15 kg/ha) could produce the longest leaf (97.2.cm) and maximum number of harvestable leaves (139.87 x 10^3) in sisal. For obtaining maximum fibre yield in sisal, application of either drip-irrigation @ 4 l/ha for 4 hrs at 2 weeks interval during 14-23 SMW together with zinc sulphate 20 kg/ha + borax 15 kg/ha (1546 kg/ha), or with drip-irrigation @ 4 l/hr for 2 hrs at 2 weeks interval together with zinc sulphate 20 kg/ha + borax 15 kg/ha (1493 kg/ha) are suggested. Application of micronutrients (zinc sulphate 20 kg + borax 15 kg/ha) together with drip-irrigation (4 l/hr for 2 hours at 2 weeks interval during 14-23 SMW) gave the highest water use efficiency (4.52 kg/ha-mm) in sisal. Water use efficiency is reduced if the drip-irrigation (4 l/hr at 2 weeks interval) was prolonged for 4 hours (3.46 kg/ha-mm). Application of micronutrients such as Zn and B are suggested for sisal grown in the central plateau zone of India, as the highest Zn content (19.3 ppm) was recorded in treatments where zinc sulphate (@ 20 kg/ha) together with borax (@ 15 kg/ha) was applied in soil. Similarly the highest B content (14.4 ppm) was also found in zinc sulphate (@ 20 kg/ha) + with borax (@ 15 kg/ha) applied cases.

References

Anonymous. 1992. Crop water requirements. FAO irrigation and drainage paper 24. Food and Agricultural Organization of UNO, Rome.

Anonymous. 2002. Crop water requirement and irrigation scheduling. Irrigation Manual Module 4. Food and Agricultural Organization of UNO, Rome.

Davis, S.C., Kuzmick, E.R., Niechayev, N. and Hunsaker, D.J. 2017. Productivity and water use efficiency of *Agave Americana* in the first field trial as bioenergy feed store on arid lands. *Global Change Biology Bioenergy*, 9: 3140325.

Kundu, D.K., Sarkar, S., Saha, A.R., Jha, A.K. and Abdullah, Sk. 2013. Growth and fibre yield of sisal as influenced by irrigation and application of micronutrients. *JAF News*, 11 (1): 13-14.

Mekonnen, M.M. and Hoekstra, A.Y. 2011. The green, blue and grey water footprint of crops and derived crop products. *Hydrology and Earth System Sciences*, 15: 1577-1600.

Nobel, P.S., Quero, E. and Linares, H. 1988. Differential growth response of Agaves to nitrogen, phosphorus, potassium and boron applications. *Journal of Plant Nutrition*, 11 (12): 1683-1700.

Pinkerton, A. 1971. Some micronutrient deficiencies in sisal (*Agave sisalana*). *Experimental Agriculture*, 7: 113-122.

Riaz, S., Aftab, B., Sarwar, M.B., Batool, F., Iqbal, F., Ahmed, Z., Rashid, B. and

Husnain, T. 2016. Adaptations of plant responses in *Agave sisalana* under drought stress conditions. *Journal of Biodiversity and Environmental Sciences*, 9 (4): 114-123.

Saha, A.R. 2001. Assessment of yield potential and effect on life span of *Agave sisalana* and Bamra Hybrid under irrigated and rainfed condition. *CRIJAF Annual Report*, 2000-2001; pp 117-118.

Sarkar, S. 2015. Sisal: Its scope as a multi-dimensional fibre crop for India. *Indian Farming*, 65 (5): 2-7.

Sarkar, S. and Jha, A.K. 2017. Research for sisal (*Agave* sp.) fibre production in India. *International Journal of Current Research*, 9 (11): 61136-61146.

Sarkar, S., Jha, A.K., Majumdar, B. and Saha, A.R. 2018. Influence of drip-irrigation, manure and fertilizers on production of planting materials in sisal (*Agave sisalana* Perr. Ex Engelm.). *International Journal of Current Microbiology and Applied Sciences*, 7 (9): 1934-1941.

Sarkar, S., Kundu, D.K. and Mahapatra, B.S. 2013. Rainfall probability analysis of the western Odisha plateau region for sisal (*Agave sisalana* Perrine ex Engelm.) based cropping system. *Journal of Agricultural Physics*, 13 (1): 62-70.

Sarkar, S., Saha, A.R. and Majumdar, B. 2017. Fibre yield estimation in sisal (*Agave sisalana* Perr. Ex Engelm.) through regression equation based on simple biometric observations. *International Journal of Current Research*, 9 (3): 47853-55.

Shalhevet, J., Mantell, A., Bielorai, H. and Shimshi, D. 1979. Irrigation of field and orchard crops under semi-arid conditions. *IIIC Publication No. 1*, International Irrigation Information Centre, at Agricultural Research Organization, Volcani Centre, Volcani, Israel, p 124.

How to cite this article:

Kundu, D.K., S. Sarkar, A.R. Saha, A.K. Jha and Behera, M.S. 2018. Application of Micro-Irrigation and Micro-Nutrients to Improve Fibre Yield and Water Use Efficiency in Sisal (*Agave sisalana* Perr. Ex Engelm.). *Int.J.Curr.Microbiol.App.Sci.* 7(10): 2101-2108.
doi: https://doi.org/10.20546/ijcmas.2018.710.242