

Impact of drip irrigation in sugarcane cultivation in Mandya district of Karnataka, India

ABSTRACT

This study investigates the impact of drip irrigation on sugarcane cultivation in Mandya district, Karnataka, considering the challenges posed by traditional flood irrigation methods and the increasing demand for water resources. The research compares the adoption of drip and flood irrigation, analyzing socio-economic characteristics, cropping patterns, and the comparative economics of sugarcane cultivation under both methods. **Externality concept and Partial budgeting technique was emphasized to estimate the additional benefit derived from drip irrigation over flood irrigation.** The study reveals that drip irrigation leads to higher water use efficiency, improved crop quality, and environmental sustainability. The adoption of drip irrigation in **sugarcane cultivation** results in significant economic benefits, with higher net returns and increased yields **then farmers following flood irrigation.** The findings highlight the positive externality associated with drip irrigation, contributing to water conservation, reduced labor costs, and increased agricultural **sustainability with an additional benefit of around Rs. 41,000 derived due to drip adoption over flood irrigation in Sugarcane cultivation.** As Karnataka faces evolving challenges in agriculture, the widespread adoption of drip irrigation emerges as a pivotal factor in ensuring the prosperity of sugarcane cultivation and addressing environmental concerns.

Keywords: *Drip Irrigation, Sugarcane Cultivation, Water Use Efficiency, Externality, Comparative Economics, Agricultural Sustainability*

1. INTRODUCTION

In India, irrigation accounts for a large share of fresh water use and more than 90 per cent of groundwater use [3]. Food security and a growing population have increased the demand on water resources [5]. The country has reached a point where the availability

of fresh water is stable but the demand for water from diverse economic sectors is rapidly rising. In addition, excessive water consumption damages the environment by causing salinity to rise, deterioration, nutrient pollution, and the loss of wetlands and floodplains [14]. India suffers from a prolonged water deficit as a result of inadequate water resource management and climate change [8].

Sugarcane cultivation is a vital component of Karnataka's agricultural landscape, particularly in regions like Mandya district. The choice of irrigation method plays a crucial role in the success and sustainability of sugarcane farming [12]. However, traditional methods of sugarcane cultivation often posed significant challenges, particularly in managing water resources effectively. In Karnataka, sugarcane growers primarily employ two main irrigation techniques: flood irrigation and drip irrigation. These methods have distinct advantages and challenges, and their adoption has far-reaching implications for crop yield, water resource management, and the environment [13].

1.1 Flood/furrow Irrigation

Flood irrigation, a more traditional method of watering sugarcane fields, involves flooding the fields with water from canals or other water sources. This method has been widely practiced in Karnataka and offers its own set of advantages. It is a relatively simple and cost-effective approach that requires less initial investment compared to drip irrigation. However, flood/furrow irrigation is less water-efficient, as it can result in substantial water wastage due to evaporation, runoff, and uneven distribution. Over time, this inefficiency has led to increased pressure on water resources in regions like Mandya, where water scarcity is a growing concern [11].

1.2 Drip Irrigation

Drip irrigation is a precise and efficient method of watering crops that has gained popularity in sugarcane cultivation across Karnataka. This system delivers water directly to the root zone of individual plants through a network of tubes, pipes, and emitters. Drip irrigation offers several benefits for sugarcane farmers in the region. It allows for precise control over the amount and timing of water and nutrient delivery, conserving water resources and improving crop quality. The technology not only enhances sugarcane

yields but also mitigates the risk of diseases associated with over-irrigation. Moreover, drip irrigation is eco-friendly, as it minimizes water wastage and reduces the environmental impact of sugarcane farming. However, it requires substantial initial investment and regular maintenance [10].

In this context, the choice between drip and flood irrigation in sugarcane cultivation in Karnataka involves a trade-off between efficiency, environmental impact, and economic considerations. Farmers must carefully assess the specific needs of their fields, available resources, and the prevailing environmental conditions to make an informed decision. As water resources become increasingly scarce, the adoption of modern irrigation techniques like drip irrigation is gaining momentum, promising a more sustainable and prosperous future for sugarcane farming in the state.

In recent years, the adoption of drip irrigation has brought about a remarkable transformation in the way sugarcane is grown in this region. This article explores the significant impact of drip irrigation on sugarcane cultivation in Mandya District.

2. METHODOLOGY

2.1 Study area and sampling

This study was conducted to estimate the impact of drip irrigation in sugarcane cultivation in Mandya district of southern Karnataka (Figure 1). Selection of districts was based on the availability of water resources, cropping pattern and climatic condition. Mandya district is a Cauvery command area where in which diversified cropping pattern such as, sugarcane, paddy and vegetable cultivation could be observed based on the availability and source of irrigation water. In order to address the objectives of the study two categories of farmers were sampled which was farmers who have adopted drip irrigation and flood irrigation in sugarcane cultivation.

The primary data was collected through personal interview method for the agricultural year 2021-2022 using structured pre-tested schedule. The agricultural year 2021 is considered as normal rainfall year. The random sampling method was adopted for the selection of farm households. The selection of villages was done randomly and also the farm households were selected randomly from the selected villages. Whereas, the

sample size for adopters and non-adopters of drip irrigation was 60 each covering a sample frame of 120 farm households Mandya district.

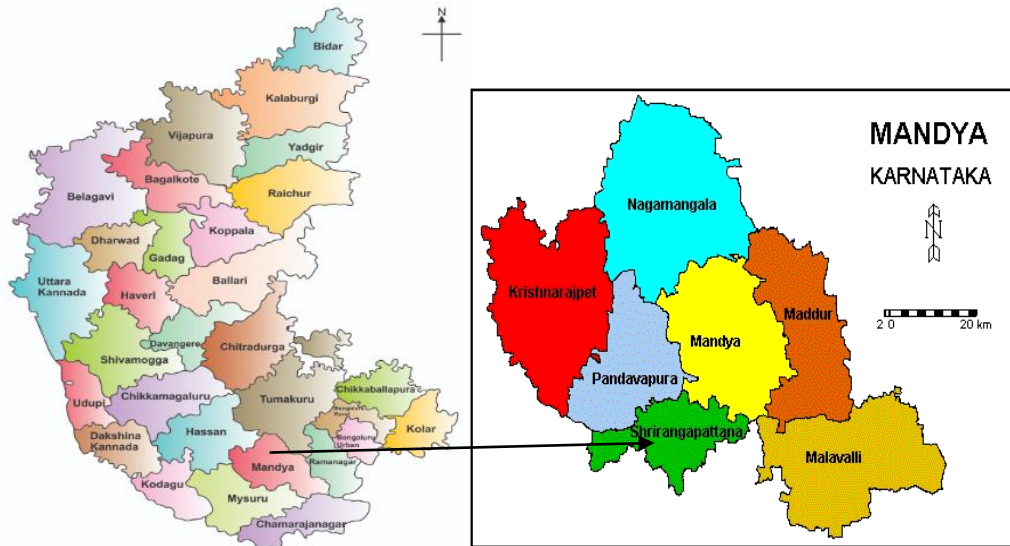


Fig. 1: Map showing study area

2.2 Analytical tools employed

2.2.1 Descriptive analysis

Quantitative data was analyzed using descriptive statistics such as mean, percentage, ratio and frequency distribution. In the present study, these techniques were employed to present the data on socio-economic profile, asset position of the farmer respondents, number of households and adopters of micro irrigation, irrigation productivity details *etc.*

2.2.2 Cropping pattern

The Gross Cropped Area (GCA) was worked out as the sum of area of irrigated crops in all seasons (kharif, rabi and summer including perennials) + area under dry land crops. The Net Cropped Area (NCA) was computed as the sum of area under irrigated crops for kharif season + area under dry land crops during kharif season. Gross Irrigated Area (GIA) was estimated as the sum of irrigated area under all crops in all seasons. Net Irrigated Area (NIA) is the irrigated area under all crops in kharif

season and one season of perennials. Accounting gross cropped area of perennial crops such as, mango, and mulberry, guava and rose crop area is considered as thrice the area under each perennial crop to give weightage to their year-round crop stand in the field. Similarly, banana and sugarcane area were treated as thrice the area under perennial crop. For coconut crop the area was treated as one and half times.

2.2.3 Simpson Diversity Index

To assess the diversification of crops across sample categories using borewell irrigation, Simpson Diversity Index was used [9]. The index ranges from 0 to 1. If the index is closer to 1 it reveals high diversification while if the index is close to 0 it reflects low diversification. It is computed as below

$$\text{Simpson's Index} = 1 - \sum_{t=1}^n P_t^2$$

Where, P_i is the proportion of area under each crop in acres to the total gross cropped area.

2.2.4 Returns/Income

- a) **Gross returns:** Obtained by multiplying the total produce with its unit price.

$$\text{Gross returns} = \text{Total output} \times \text{Price of output}$$

- b) **Net returns:** Obtained by subtracting total cost from gross returns.

$$\text{Net returns} = \text{Gross returns} - \text{Total Cost}$$

2.2.5 Externality cost

In hard rock areas, each one's extraction of groundwater is not independent of the other, but is interdependent on the extraction by neighbouring well(s) at a time and over time. This results in reciprocal negative externality, as all the users of groundwater impose external costs on all other users simultaneously and over time. In the case of

unidirectional externality, a farmer by drilling deeper and/or increasingly extracting groundwater inflicts externality on others and on himself at a time and over time due to interference of well/s. Over time, all farmers pumping groundwater impose external costs on all others, including upon themselves due to cumulative interference, and this is the phenomenon of reciprocal externality [2].

An estimate of externality per borewell was obtained by the difference between the amortized per functioning well (obtained dividing the total amortized cost by the number of functioning wells on the farm) minus amortized per well (obtained dividing the total amortized cost by all the wells on the farm). Thus, if there are no failed wells, then all wells are functioning and there is no externality. If there are failed wells, then the hypothesis was that the failed wells are due to reciprocal negative externality and hence the difference between the two components will reflect the magnitude of negative externality, since the amortized cost per functioned well will always be higher than amortized cost per well which indicates the presence of externality. Here the failed wells are those which failed initially and the wells which did not serve even up to payback period.

Table 1: Additional costs and additional benefits associated with micro irrigation

Additional costs				Additional Benefits			
Private		External		Private		External	
Capital cost (investment cost)	Reduction in labour absorption per acre of traditionally irrigated sugarcane crop replaced by micro irrigated sugarcane cropping system.	in	labour	Value of saved water.	of	saved	Increased water availability for irrigation purposes.
Maintenance cost	Reduction in food security due to replacement of traditional cereals by	in	food	Value of labour saved.	of	labour	Reduced power energy consumption in agriculture.

	high valued vegetables, cash crops and fruits.		
Depreciation on drip equipments	Additional cost incurred towards purchase of cereals because of drip adoption.	Increase in value of outputs (due to increased yield).	Reduction in cost of well deepening.
Interest on fixed capital	-	Expansion in cropped area.	Reduction in cost of drilling new bore wells / wells Reduction in well failure.

3. RESULTS AND DISCUSSION

3.1 Socio economic characteristics of farm households of study area

The socio-economic characteristics of a person can be used to characterize household economic inequality, which reflects his/her social class, status, and economic position in society, and plays an important part in increasing the well-being of the individual family and society as a whole [5]. Household size, religion, gender, marital status, education, occupation status, income, respondent age and family patterns are all important factors considered to know the socioeconomic conditions of a household [7].

Table 2 explains the socio-economic characteristics and land holding details of the sample households in Mandya district. The adopters of drip irrigation were belong to young age group with an average age of 43 years and more educated with 10-11 years of schooling than the non adopters who belong to an average age of about 48-51 years with an average of 7 years of schooling.

Table 2: Socio economic status and land holding details of farm households across study area

Sl. No.	Particulars	Mandya district (n=120)	Kolar district (n=120)	T test value
---------	-------------	-------------------------	------------------------	--------------

		Adopters	Non adopters	Adopters	Non adopters	
1	Age (years)	43	48	44	51	2.30**
2	Education level (No.)	10.81	6.53	10.20	7.61	2.79*
3	Family size (No.)	4.10	4.31	4.57	3.60	1.13
4	Total owned land					
4a	Land holdings (ac)	3.31	2.63	5.00	3.43	3.26*
4b	Dry land (ac)	0.75	0.35	1.81	2.00	2.98*
4c	Irrigated land (ac)	2.56	2.28	3.19	1.43	2.66*
5	Total leased in land (ac)	1.30	0.31	2.11	0.42	2.43**

* - Significant at 1 %, ** - Significant at 5%

3.2 Cropping pattern of farm households in the study area

Details on the cropping pattern of drip irrigation adopters and non-adopters of the Mandya district are given in Table 3. Cropping pattern of farmers in the study area indicates that in the Mandya district, ragi, cowpea and horse gram are rainfed crops whereas all other crops such as sugarcane, paddy, fruits and vegetables grown under irrigated condition. Among micro irrigation adopters of Mandya district around 42 per cent of area under gross cropped area along goes to sugarcane cultivation and six per cent area goes to rainfed crops cultivation such as ragi and pulse crops and remaining area was irrigated which was occupied with horticultural crops like vegetables, fruits and plantation crops.

Table 3: Cropping pattern of farm households in the study area

Sl. No.	Crop	Mandya district (n=120)			
		Adopter (acre)	(% of GCA)	Non adopters (acre)	(% of GCA)

Kharif					
1	Rice	-	-	57.30	25.02
2	Sugarcane	159.6	42.44	101.7	30.67
3	Ragi	-	-	7.75	3.38
4	Ragi(RF)	7.8	3.31	6.75	2.97
5	Tomato	23.4	9.94	5.75	2.51
6	Cucumber	8.05	3.42	-	-
7	Gourds	5.25	2.23	-	-
8	Beans	7.94	3.37	-	-
9	Chilli	4.98	2.12	-	-
10	Capsicum	4.45	1.89	-	-
11	Beetroot	0.5	0.21	-	-
12	Carrot	3.25	1.38	-	-
13	Knolkhol	9.25	3.93	-	-
14	Horse gram	5.24	2.23	-	-
15	Green leafy vegetables	-	-	-	-
Rabi					
16	Tomato	11.9	5.06	-	-
17	Cucumber	13.80	5.86	-	-
18	Gourds	13.34	5.67	-	-
19	Beans	10.50	4.46	-	-
20	Beetroot	6.00	2.55	-	-
21	Cowpea	-	-	3.75	1.64
22	Chilli	6.56	2.79	-	-
23	Green leafy vegetables	-	-	-	-
Summer					
24	Rice	-	-	45.80	20.00
25	Ragi	-	-	18.34	8.01
26	Tomato	6.45	2.74	2.5	1.09
27	Capsicum	-	-	-	-
28	Carrot	-	-	-	-
29	Chilli	-	-	-	-
30	Green leafy vegetables	2.25	0.96	-	-
Perennials					
31	Mulberry	26.40	3.74	21.12	3.07
32	Mango	10.00	2.12	-	-

33	Coconut	13.99	3.96	52.83	15.38
34	Banana	15.9	2.25	15.00	2.18
35	Rose	8.40	1.19	-	-
36	Guava	-	-	-	-
	Gross cropped area	384.8	-	338.55	-
	Net cropped area	164.49	-	158.71	-
	Cropping intensity (%)	233.93	-	213.31	-
	Gross irrigated area	353.96	-	328.04	-
	Net irrigated area	137.17	-	151.96	-
	Irrigation intensity (%)	256.56	-	215.87	-
	Simpson diversity index of crops cultivated	0.88	-	0.72	-

Among non-adopters of drip irrigation in Mandya district 45, 31 and 13 per cent of gross cropped area (GCA) was taken up by paddy, sugarcane and ragi cultivation, respectively and remaining portion of GCA goes to coconut, tomato, banana and cowpea cultivation. Majority of non-adopters of Mandya district gets sufficient canal water for irrigation, most of them grew rice, ragi and sugarcane covering about 89 per cent of gross cropped area.

Gross cropped area of perennial crops such as mango, mulberry and guava area was considered as thrice the area under each perennial crop to give weightage to their year-round stand. For crops such as banana, rose, sugarcane and chrysanthemum, the area under them was treated as thrice the area under perennial crops. Only for coconut it was treated as one and half times the area under perennial crop because of wider plant spacing as compared to plant spacing of above-mentioned perennials. This justifies the year round stand of perennial crops.

The cropping intensity of micro irrigation adopters of Mandya district was 233 per cent. The irrigation intensity of adopter farmers in Mandya district was around 256 per cent may be due to large area in Mandya district was under sugarcane and gross

irrigated area for sugarcane was considered thrice the area of its cultivation to capture three seasons effect.

3.3 Comparative economics of sugarcane cultivation under drip irrigation and furrow irrigation situation in Mandya district

Table 4 is detailed about the comparative economics of sugarcane cultivation under drip irrigation and furrow irrigation situation. Sugarcane was the major crop cultivated in Mandya district. In Mandya district, Pandavapura and Maddur taluk showed sugarcane cultivation under both the furrow and drip irrigation situations. As some part of both the taluks were more elevated and they were not able to get the canal water from Krishna Raja Sagara dam. Hence, they are using ground water as major source of irrigation for crop cultivation.

Table 4: Estimation of economics of sugarcane cultivation under with and without drip irrigation situation in Mandya district (per acre/crop)

Sl. No.	Cost Particular	Sugarcane (furrow)	Sugarcane (drip)	% difference
1	Seeds and seed material (Rs.)	7038	7276	3.38
2	FYM and silt (Rs.)	7463	10878	45.76
3	Fertilizers (Rs.)	14864	11954	-19.58
4	PPC (Rs.)	6246	9693	55.19
5	Total human labour cost (Rs.)	24835	18654	-24.89
6	Bullock labour cost (Rs.)	3795	3570	-5.93
7	Machine labour cost (Rs.)	4400	3885	-11.70
8	Irrigation (acre inch)	101.5	58.3	-42.56
9	Total variable cost (Rs.)	73138	70524	-3.57
10	Total fixed cost (Rs.)	27419	36188	31.98
11	Marketing cost (Rs.)	33624	44190	31.43
12	Total cost (Rs.)	134180	150902	12.46
13	Yield of main product (q)	620.36	736.5	18.72
14	Gross returns (Rs.)	176927	210123	18.76
15	Net returns (Rs.)	42746	59222	38.54
16	Net returns with IR cost (Rs.)	42746	36834	-13.83

17	Returns per rupee of total cost (Rs.)	1.32	1.39	5.60
18	Cost of production (Rs. / tonne)	2163	2049	-5.27

In canal irrigated areas, sugarcane was cultivated using surface water throughout the cropping period, but in elevated areas where ground water was the major source of irrigation. In this situation, sugarcane was cultivated through furrow method of irrigation upto starting 3 months of cropping period and after that till the end of cropping period they go for drip irrigation.

Therefore, water irrigated for sugarcane under furrow irrigation was 101.5 acre inches and under drip irrigation it was about 54.2 acre inches which was 43 per cent lesser than the furrow irrigation. Similarly, sugarcane cultivation under furrow irrigation consumes 25 per cent more labour than the cultivation of sugarcane under drip irrigation. Micro irrigation adopters gets 39 per cent higher net returns than non-adopters of micro irrigation of Mandya district as they get 19 per cent higher crop yield. It was found that, sugarcane crop cultivators with drip irrigation were more profitable than the non drip irrigation adopters in sugarcane cultivation due to higher water use efficiency and better yield.

3.4 Additional benefit derived from adoption of drip irrigation in Sugarcane cultivation in Mandya district

Table 5 gives details on additional benefit derived from adoption of micro irrigation in sugarcane cultivation. Left hand side of the table is detailed about positive effects of adoption of drip irrigation system in cultivation of sugarcane and right hand side was detailed about negative effects of adoption of micro irrigation. Drip irrigation makes it easier for farmers to irrigate when it is required and meanwhile it saves labour required for irrigation and weeding. Hence, compared to conventional irrigation, drip farmers saves around 48 acre inches of water cost worth of Rs.19, 203 and also saves electricity cost of Rs. 1,996. Since drip irrigation increases the water use efficiency, there was increase in yield of sugarcane in an acre plot with an increase in gross return

of Rs. 22,884. Added input costs per acre of sugarcane plot and annual maintenance cost of bore well and drip irrigation system was Rs. 6,980. Therefore, the additional benefit derived from drip adoption in the sugarcane cultivation was more than the additional cost incurred in drip adoption, which was about Rs. 41,029, which is the additional benefit derived from the drip irrigation system adoption over furrow method of irrigation in sugarcane cultivation in Mandya district.

The findings are in line with the study conducted by Dineshkumar, 2016 [4] who reported adoption of sprinkler irrigation system in command areas can increase the water use efficiency in crops inter alia increases the social benefit than the social cost incurred for subsidy giving. Hence, the hypothesis on positive externality associated with micro irrigation in sugarcane cultivation is accepted.

Table 5: Partial budgeting for adoption of drip irrigation system for Sugarcane cultivation in Mandya district

Positive effects		Negative effects	
Additional return	Value (Rs.)	Reduced return	Value (Rs.)
Increase in gross return	22,884	---	---
Reduced cost	Value (Rs.)	Added cost	Value (Rs.)
Labour cost	3,926	Seed and seed materials	438
Fertilizer		FYM	1,415
Value of water saved	19,203	PPC	447
Reduced electricity cost	1,996	Maintenance cost of drip and borewell structure	4,680
Total	48,009	Total	6,980
Additional benefit derived		41,029	

It was found that, drip irrigation increases the water use efficiency, reduces labour cost and also increases the yield level resulting into the increase in net returns.

In addition to these parameters, it increases the ground water availability for other farmers, there can be agricultural area expansion for cultivation. Further, it reduces the cost of well deepening and well failures if any and also reduces the power energy consumption in agriculture. Hence, there is positive externality from adoption of drip irrigation system in the study area.

Karnataka, the country's second-driest state after Rajasthan, is a pioneer in drip and sprinkler irrigation, which saves water, energy, and labour while also assisting farmers in coping with groundwater constraint (Chandrakanth et al., 2013) ([1]). The hypothesis that there is positive externality from drip adoption in sugarcane cultivation in the study area is accepted.

4. CONCLUSION

Sugarcane cultivation is a vital component of Karnataka's agricultural landscape, particularly in regions like Mandya district. The choice of irrigation method plays a crucial role in the success and sustainability of sugarcane farming. As Karnataka continues to evolve and face new challenges in the agricultural sector, the widespread adoption of drip irrigation is poised to play a pivotal role in ensuring the prosperity of sugarcane cultivation while safeguarding the environment. The adoption of drip irrigation in sugarcane cultivation has brought about a transformative impact in Mandya district, Karnataka. In addition to saving labor for weeding and irrigation, drip irrigation facilitates farmers' ability to irrigate when needed. As a result, drip farmers save about Rs. 19,203 in water costs and Rs. 1,996 in electricity costs as compared to conventional irrigation. This technology has not only addressed water scarcity issues but also improved crop yields, quality, and overall agricultural sustainability. It has simultaneously benefitted farmers by reducing labor costs and increasing income. The additional benefit derived from drip irrigation adoption in the sugarcane cultivation was more than the additional cost incurred in drip adoption. Hence, there is a positive externality associated with the sugarcane cultivation adopted with drip irrigation than traditional method of irrigation system. Furthermore, drip irrigation aligns with global environmental concerns by promoting water conservation and soil health.

REFERENCES

1. Chandrakanth MG, Priyanka CN, Mamatha P, Patil KK. Economic benefits from micro irrigation for dry land crops in Karnataka, Ind. J. of Agri . Econ, 2013; **68**(3): 327-338.
2. Dasgupta P. The control of resources, Cambridge, 1982; MA: Harvard university press.
3. Devineni N, Perveen S, Lall U. Solving groundwater depletion in India while achieving food security, Nature Communications, 2022; **13**: 1-10.
4. Dinesh Kumar M. Water saving and social benefits from micro irrigation: a study from IGNP command area in Rajasthan. Micro Irrigation Systems in India, 2016; pp: 91-112.
5. Galobardes B. Indicators of socioeconomic position (part 2). J. Epid. and Comm. Health, 2006; **60**(2), 95–101. doi: 10.1136/jech.2004.028092.
6. Information brief on Water and Agriculture in the Green Economy. UNW-DPAC, 2011.
7. Jiboye A. An Assessment of the influence of socio-cultural factors on housing quality in Osogbo, Nigeria. Master's Thesis (Unpub.), Obafemi Awolowo University. 2004;
8. Mishra BK, Kumar P, Saraswat C, Chakraborty S, Gautam A. Water Security in a Changing Environment: Concept, Challenges and Solutions. Water-MDPI, 2021; **13**: 1-21.
9. Muthappa PP. A resource economic study on tree diversity in coffee-based plantations in the Western Ghats region of Karnataka, M.Sc (Agri.) Thesis (unpub), 2000; Univ. of Agri Sciences, Bengaluru.
10. Rajkumar A, Sudhanshu S, Aastha T, David JO and Yadvendra PS. Micro irrigation: The water saving technology, 2023; **12**(6): 2386-2393.
11. Sethi RR, Jena SK, Renuka Rani B and Jamanal SK. Advanced Water Management Technology for Enhancing Agricultural Productivity, ICAR -

- Indian Institute of Water Management (ICAR – IIWM) Bhubaneswar, National Institute of Agricultural Extension and Management (MANAGE).
12. Shukla SK, Sharma L, Awasthi SK, Pathak AD. Sugarcane in India; Package of Practices for Different Agro-climatic Zones. ICAR-All India Coordinated Research Project on Sugarcane, 2017; Page No. 1-64.
 13. Surendran U, Jayakumar M, Marimuthu S. Low cost drip irrigation: Impact on sugarcane yield, water and energy saving in semiarid tropical agro ecosystem in India. Science of The Total Environment, 2016; **573**: 1430-1440.
 14. Vibha D, Water and Agriculture in India, Background paper for the South Asia expert panel during the Global Forum for Food and Agriculture (GFFA) 2017; OAV – German Asia-Pacific Business Association within the frame of the Bilateral Cooperation Project on the Development of International Cooperation with Asia, co-funded by the Federal Ministry of Food and Agriculture (BMEL).