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# Cost reduction and increase of income to farmers through adoption of certain economically direct measurable important technologies for bivoltine sericulture

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**Abstract**
Scientific way of practicing sericulture through timely adopting recommended simple agro-ergonomic practices in the field at famers' level has brought tremendous improvements on the utilization efficiency of natural resources like irrigation water, manpower, fertilizer input involved in mulberry cultivation and in silk worm cocoon crops, with increased quality linked productivity of mulberry leaves facilitated more disease free silkworm layings (dfls) brushing and quality cocoon production at less cost which doubled net income to farmers tackling constraints on irrigation water, skilled workers non-availability, its high costs and increased prices of inputs.
Soil nutrients status of mulberry garden of 100 sericulture farmers @ 20 from 5 regions tested revealed that average organic carbon content of 0.64% (0.07-1.36%), phosphate 16.07 (5.4-32.1 kg/ha) and high in potash of 545.99 (89.6-985.6 kg/ha) with average 7.76 pH (6.41-9.12) and electrical conductivity 0.20 (0.034-0.956 mmhos/cm). All the farmers identified were sensitised on the basic principles and importance of recommended simple agro-ergonomic practices adoption in time and closely monitored for two years (2020-'21 and 2021-'22). The studies revealed that significant improvements on the utilization efficiency of all direct measurable economic inputs with adopted farmers. Irrigation Water Use Efficiency (WUE) in terms of leaf productivity per ha mm irrigation water used increased to 129.91% with 61.23% irrigation water savings, Human Resource Use Efficiency (HRUE) in terms of work output man days utilised increased to 87.75% with equal man days savings, Fertilizer Use Efficiency (FUE) in terms of leaf productivity increased to 42.57%. Quantum of dfls rearing & production of cocoons per unit area increased to 44.83 & 72.87% respectively, whereas the overall production cost decreased by 98.98% and the net income through sale of cocoons alone with quantum jump increase of 81.80% more when compared to the non-adopters. The Benefit Cost Ratio recorded as 3.54 and 1.7 with adopters and non-adopters respectively. The results were statistically significant in all parameters studied. The study details are discussed in the paper.

**Keywords:** Agro-ergonomic, Cocoons, Cost, DFLs, FUE, HRUE, Income, Productivity, Quality, WUE

## Introduction

Cultivation of mulberry (*Morus* spp.) (on-farm) for its leaves the sole food for silkworm (*Bombyx mori* L) rearing (off-farm) for production of silk cocoon, the raw material for silk yarn under agriculture part at farmers' level; production of raw silk (reeling), processing of silk yarn *viz*., doubling, twisting, bleaching, dyeing, warp & weft making and weaving etc., for fabric production under industrial part.
India is second largest silk producing country with 34,903 t raw silk production (2021-'22) in the world and is unique in production of all known four varieties of natural silk namely mulberry, tasar, eri and muga. Of the total mulberry silk of 25,818 t produced in the country about 73.97% is produced from the traditional sericulture states namely Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Jammu & Kashmir (Anonymous, 2022). In India 2.42 lakh ha area is under mulberry cultivation and 8.54 million people get employment through sericulture. About 80% of mulberry garden is under irrigated condition which shows the importance of irrigation for the crop. In Tamil Nadu presently sericulture is practiced in 29 districts with 20,121ha. mulberry area by 23,873 farmers and 2.23 lakh people get employment. Scarcity of irrigation water, manifold increase in price of inputs, non-availability skilled man power and high labour wages collectively attributes increase in cost of production and less profit, poses threat to agriculture, sericulture being labour intensive agro-based cottage industrial nature of activity, the problem aggravates further.
Water demand and supply gap is increasing year after year and shrinkage in availability is posing major threat globally in near future. International Water Resource Economics Consortium (IWREC) in its 12th annual meet report (Anonymous, 2016) [3] stated that globally, current withdrawals of about 4500 km$^3$ exceeds the availability of about 4200 km$^3$; by 2030, the demand is expected to increase to 6900 km$^3$; with a slight drop in availability to 4100 km$^3$ result with a deficit of 40% and for India, the annual demand is expected to increase to almost 1500 km$^3$, as against a projected availability of 744 km$^3$, a deficit of 50% (Narasimhan, 2010) [23].Rainfall is the main water source southern peninsula of our country, due to lack of perennial rivers as available in central & northern regions.
Worldwide agriculture is the single biggest drain on water supplies, accounting for about 69% of all use, about 23% of water meets the demands of industry & energy and just 8% goes for domestic & commercial use (Anonymous, 2002) [2].
In India, agriculture sector uses about 93% of water whereas

industry and domestic & commercial sectors use 3 & 4% respectively (Rakesh kumar *et al.*, 2005). Massive shifting of irrigation from surface water to ground water from the level of about 33% during 1960's to more than 60% in three decades reduced the ground water level and its quality significantly (Swaminathan, 1994) [39].

Scarcity of irrigation water for mulberry cultivation due to low rainfall or failure of monsoon or frequent drought is the major limiting factor for the industry (Rajaram *et al.*, 2006, 2016) [28, 29].Mulberry requires about 1.5-2.0" acre water per irrigation at an interval of 6-12 days depending upon the type of soil and seasons. About eight number of irrigation is required per crop of 65-70 days duration to achieve the maximum leaf yield. Thus the annual requirement of irrigation water for 5 crops is about 75" acre equal to 1905 mm rainfall distributed equally @ 36.63 mm per week or 5-6 mm per day. But 80% of average annual rainfall of 1,160 mm (Lal, 2001[15]; Gupta and Deshpande 2004) of our country is received in 4-5 months and in Tamil Nadu, 961.8 mm. is received in 40-45 days; hence the irrigation demand for mulberry crop is not possible to meet by rainfall alone.

Mulberry leaf quality; as individual factor contributes about 38.2% for the success of silkworm cocoon crop (Miyashita, 1986) [22]. Quality mulberry leaf possesses all nutrition required for better growth of silkworm to form quality cocoon is adjudged by the better growth of mulberry from good soil supplied with adequate inputs. Ray (1978) [33] applied N fertilizer @ 150, 300, 600, and 900 kg $ha^{-1}yr^{-1}$ and observed that leaf yield increased by 88% in the highest dose. The yield of mulberry is influenced more by the amount of nitrogenous fertilizer than phosphorus and potassium (Kasiviswanathan*et al.*, 1979) [13].

Deep and repeated ploughing in mulberry garden before monsoon and covering the exposed soil with paddy straw / dry weed during dry season check the growth of weeds, retains soil moisture and prevent surface evaporation of water was reported by Prasad *et al.*, (1993) [25]. Soil with crumb structure having higher microbial activity, cation exchange and organic matter content, sufficient moisture and pH in the range of 6.5-7.5 EC < 1.0 $DSm^{-1}$, (Subbaswamy *et al.*, 1994) [38] and adequate spacing for optimum number of plant population and supply of recommended doses of organic manure @ 25 t (FYM / Compost) and chemical fertilizers N:P:K @ 300:120:120 $kgha^{-1}yr^{-1}$ (Dandin *et al.*, 2005 and Rajaram and Rajan, 2008) [9, 27]. In fact, yield of most crop plants increase linearly with the amount of fertilizer they absorb and crop plants, however, typically use less than half of the fertilizer applied (Loomis and Conner, 1992) [17]. Mulberry crop response to water and fertilizer in terms of productivity increase by >400% compared to rainfed condition and amazing adaptability to different levels of soil moisture stress & fertilizer levels reported by. (Chung *et al.*, 1980; Benchamin *et al.*, 1997; Greef*et al.*, 1999; Mariga*et al.*, 2000; Hamid and Nasab, 2001) [7, 8, 10, 12, 20].

Application of more organic manure, irrigation water inalternate furrows avoid bottom pruning during summer increase soil moisture (Mishra *et al.*, 1997). Rama Kant *et al.*, (1998) [21, 32] reported application of water-soluble fertilizers through drip saves 30 to 40 % of fertilizer and save man power requirement in mulberry cultivation. Mallikarjunappa *et al.*, (1998) [19] in a separate study recorded maximum leaf yield under 6 crops / year in leaf harvest and 5 harvestper year with shoot harvest method. Maximum leaf yield without affecting the qualities and 30% water savings under drip irrigation @ 4 lr $Plant^{-1}$ in alternate days in K2 mulberry was reported by Magadum *et al.*,(2004) [18].

Importance of mechanisation, use of small machines at reasonable prices bysmall holdings to minimize the drudgery of small farmers, increase the efficiency of inputs-use and save farmers' time for enabling them to take up income-augmenting supplementary enterprises such as dairying, goat keeping and sericulture, the use of modern time-saving farm implements of appropriate size (Kulkarni, (2005) [14].Satish verma and Dandin, (2006) through mechanisation in mulberry sericulture brought out HRUE Index for various works involved. Use of electric operated mulberry shoot harvest and pruning machines in China and Japan in on-farm activity and complete fuel free machines in indoor silkworm activities are in practice (Liang Pei-Sheng *et al.*,(2008) [16].Use of Mini Power Tillers cum Inter-Cultivation Equipment (MPT-ICE) operational with AC/DC current / HSD for use in closure plantation (2'x2') in mulberry and other devices to carryout agronomical works like weeding, bund/channel making, fertiliser application in mulberry cultivation and Biomass Peeling & Cutting Machine (BPCM), Bed-disinfectant Application Machine (BAM) and Shoot Harvest Equipment (SHE) Weed Mower © Shoot Harvest / Pruning Machine (WM©SH/PM) in sericulture help to reduce drudgery and reduce cost of production significantly (Rajaram and Rajan(2008); Rajaram (2010), Rajaram and Nirmalkumar 2016) [26, 27, 28].

The study was aimed at to measure the impact of recommended simple agro-ergonomic practices adoption in mulberry cultivation in order to save natural resources like irrigation water, manpower, fertilizers, cost reduction and increase income to sericulture farmers.

**Materials & Methods**

Research Extension Centre, Srivilliputtur of CSR&TI., Mysuru, Central Silk Board is rendering technical supportsto sericulture farmers in 4 southern districts *viz*., Virudhunagar, Tirunelveli, Thoothukudi and Kanyakumari since March 2009 through the 7 Technical Service Centres of the state department of sericulture, Tamil Nadu, located Mulberry is cultivated in 2385.65 acres by 1073 farmers in 42 taluks. Out of 17.38 lakh ha. total land area (13% of state), 2.31 lakh acres of cultivable waste land available with enormous man power, non-competitive cash crops and lack of industries are the rich potentialities for further expansion mulberry area and development of sericulture for augmentative employments generation & improvement of rural economics (Anonymous, 2017) [5] (Fig.1).


**District wise Land Distribution (in lakh ha)**

| Dist. | Total | Forest | Non-agric | Barren | Horti - crop | Pas-tures | Crop area | waste | Fallow |
|---|---|---|---|---|---|---|---|---|---|
| VNR | 4.24 | 0.26 | 0.71 | 0.05 | 0.06 | 0.01 | 1.14 | 0.10 | 1.92 |
| TNV | 6.76 | 1.28 | 1.03 | 0.30 | 0.08 | 0.05 | 1.28 | 0.36 | 2.38 |
| TKD | 4.71 | 0.11 | 0.76 | 0.20 | 0.37 | 0.05 | 1.76 | 0.48 | 0.96 |
| KK | 1.67 | 0.54 | 0.29 | 0.04 | 0.01 | 0.00 | 0.76 | 0.00 | 0.03 |
| Total | 17.38 | 2.19 | 2.79 | 0.58 | 0.52 | 0.11 | 4.95 | 0.93 | 5.30 |
| % | 100.00 | 12.62 | 16.06 | 3.34 | 3.00 | 0.64 | 28.47 | 5.37 | 30.50 |

**Fig 1**

The study was carried out under Srivilliputtur cluster in 5 different locations covering a total of 100 farmers @ 20 farmers of 10 in each category in Tirunelveli district. Based on the limited irrigation water facility thro' bore wells (>800 feet depth) in the area farmers prefer MR2 mulberry variety (35-40 t leaf yield $ha^{-1}$ $yr^{-1}$) for regular silkworm crop throughout year. However V1 mulberry variety (50-60 t leaf yield $ha^{-1}$ $yr^{-1}$) are cultivated by farmers where assured irrigation facility available. The mulberry garden established with MR2 variety under (150+90) x 60 cm of Paired Row System plantation of 5 years old selected for the study. Ten farmers with facilities like drip irrigation system, use simple machines like power weeder, mini tillers, channel / bund making / fertilizer application devices, shoot harvester / pruner to adopt all recommended simple agro-ergonomic technologies in time under adopter category, the other ten farmers who carry out all agronomic works conventionally were grouped under non-adopters. Soil test of all 100 farmers mulberry garden were done before commencement of the study and demonstrated them test based application of chemical fertilizers in addition to organic basal manure. Irrigation water application equal to the value of 50% of for mulberry crop water requirement based on crop coefficient approach using the FAO's modified Penman-Monteith formula (Richard G. Allen *et al.*, 1998) [34] in CROPWAT and fertilizer application by fertigation under drip irrigation scheduled alternate days and 1.5 acre inch per irrigation and fertilizer application in furrows covered by soil under furrow irrigation system scheduled at 50% soil moisture depletion (SMD). All other package of practices recommended for mulberry garden maintenance was followed as described by Dandin *et al.*, (2005) [9].All the identified farmers were sensitised through awareness campaigns, field demonstration, group discussions etc., on the timely adoption of technologies for completion of all works in time to harvest maximum quality linked production of leaves in all five crops a year and closely monitored by frequent field visits.

The farmers were provided with log sheet for make entries of all packages carried out with quantum with supporting documents were check verified during field visit by technical staff with parallel maintenance of log sheet for each farmers for all five crops studied. The raw data collected were pooled region wise, category wise subjected to statistical analysis using AGRES Software for individual economically viable factors and a consolidated performance of the study is presented.

**Results and Discussions**

Ananthakrishna *et al.*,(1995) [1] recommended 80% $E_{pan}$ value of irrigation water under drip scheduled alternate day for optimum leaf production in K2 mulberry and was supported by Mishra *et al.*,(1997) [21]with 33% of water savings without affecting the yield. Sivanappan *et al*., (1974) [37] reported 84.7% water saving under drip irrigation compared to conventional furrow irrigation without any adverse effects on growth, yield in Bhendi and this was confirmed by Sivanappan, (1979) [36] in vegetable crops like tomato, capsicum, okra, pawpaw and bananas.

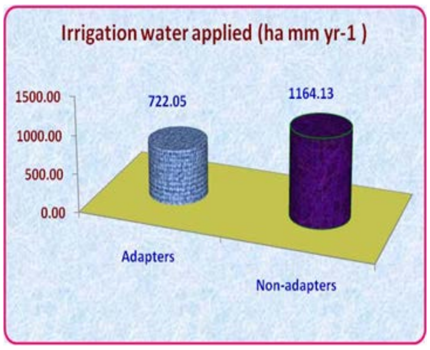
In the present study, water savings and leaf yield improvement of 61.23 and 42.61% were recorded respectively without affecting quality among adopters with drip irrigation, similarly increase of WUE and FUE by 129.91 and 80.43% respectively were recorded when compared to non-adopters under furrow irrigation supports the studies by Rajaram *et al.*, (2016) [30] in mulberry crop. The leaf yield increase at adopted farmers may be attributed by timely completion of works through mechanization, increased WUE and FUE which helped in increase of quantum of dfls rearing and cocoon production by 44.83 and 72.87 % respectively and the later might be due to qualities improvement in addition to productivity.

Simple mechanization among adopters brought significant reduction in man-days requirement and cost reduction by 87.75 and 98.98 % respectively. Net income of ` 6.38 lakh $ha^{-1}year^{-1}$ to agro-ergo technologies adopted famers as against ` 2.00 lakh $ha^{-1}year^{-1}$of non-adopters with above doubling i.e., 219.00 % increased net income to adopters are the impact of the study carried.All results recorded on various parameters shown statistically significant at CD<P 0.05 level (Table 1 Fig 2-13)

**Table 1:** Outcome of economically direct measurable important agro-ergonomic technologies for bivoltine sericulture among adopted & non-adopted sericulture farmers [Average of 5 regions @ 20 farmers (10 each of adopters & non-adopters) $ha^{-1}$ $yr^{-1}$ of 2 years study in 10 crops]

| Sl. No. | Category of farmers | Irrigation water used (mm) | Leaf pro-duction (kg) | WUE (kg/ha-mm) | FUE (% on prdn. potential) | MDs mul-berry garden maint. (No.) | DFLs consump-tion (No.) | Cocoon pro-duction (kg) | Cocoon yield / 100 dfls (kg) | Pro-duction cost / kg cocoon | Gross Income (` lakh) | Expen-diture (` lakh) | Net Income (`lakh) | BCR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 | Adopters | 722.05 | 36072.20 | 49.96 | 83.94 | 260.55 | 2604.00 | 2114.08 | 81.18 | 109.09 | 8.89 | 2.51 | 6.38 | 3.54 : 1 |
| 2 | Non-adopters | 1164.13 | 25295.53 | 21.73 | 46.52 | 489.18 | 1798.00 | 1222.94 | 68.13 | 217.07 | 4.89 | 2.88 | 2.00 | 1.70 : 1 |
| Grand Mean | | 943.0908 | 30688.7500 | 35.8450 | 64.7275 | 369.6750 | 2200.0000 | 1668.5000 | 74.6600 | 163.0000 | 6.8877 | 2.6936 | 4.1191 | 2.61 : 1 |
| SEd | | 2.9589 | 224.6002 | 0.3551 | 8.7720 | 41.0015 | 28.0401 | 26.9258 | 0.5256 | 18.8680 | 0.5682 | 0.0138 | 0.4145 | 0.2008 |
| CD @ 5 % level | | 12.7314 | 966.3950 | 1.5279 | 37.7437 | 176.4185 | 120.6493 | 115.8547 | 2.2615 | 81.1838 | 2.4450 | 0.0724 | 1.7837 | 0.8640 |
| CV% | | 0.3100 | 0.7300 | 0.9900 | 13.5500 | 11.0900 | 1.2700 | 1.6100 | 0.7000 | 11.5800 | 8.2500 | 0.6200 | 4.1147 | 7.6700 |
| Significant level | | ** | ** | ** | * | * | ** | ** | ** | * | * | ** | ** | ** |

Mm: Hamm; kg: kilogram; WUE: Water Use Efficiency; FUE: Fertilizer Use Efficiency; MDs: Mandays; Dfls: Disease Free Layings; BCR: Benefit Cost Ratio

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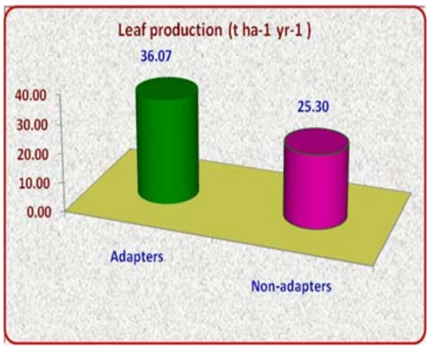


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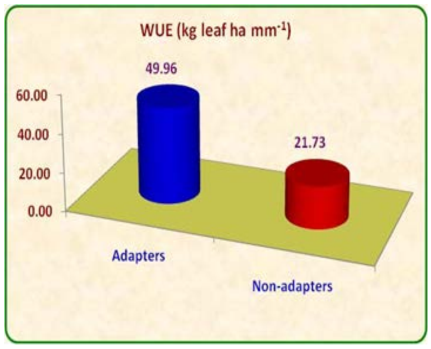


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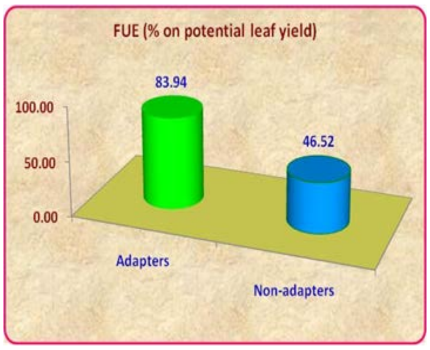


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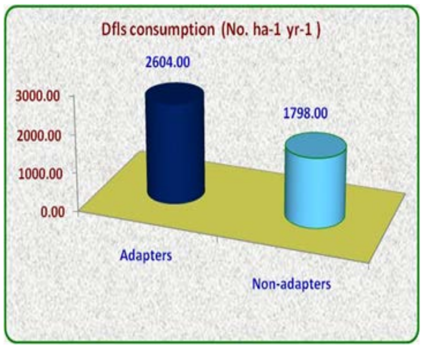


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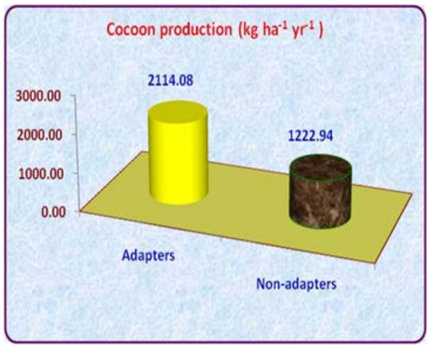


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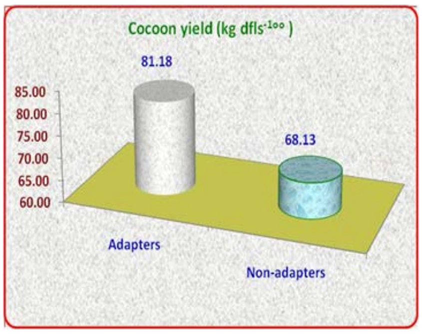


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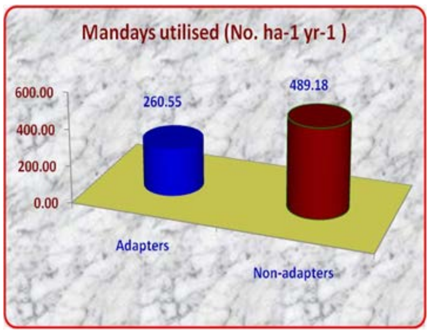


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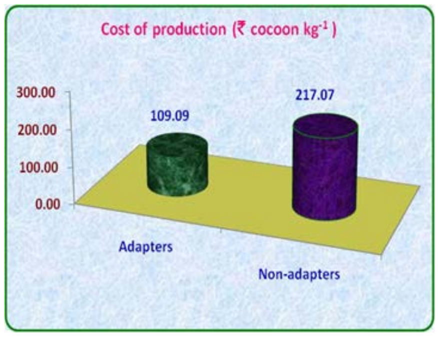


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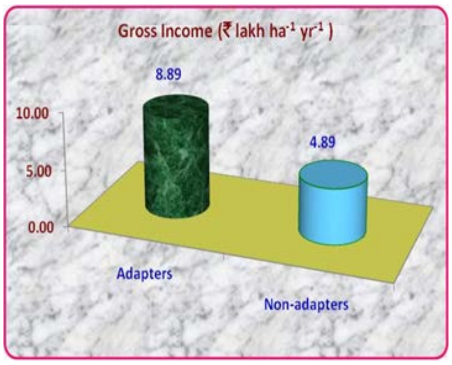


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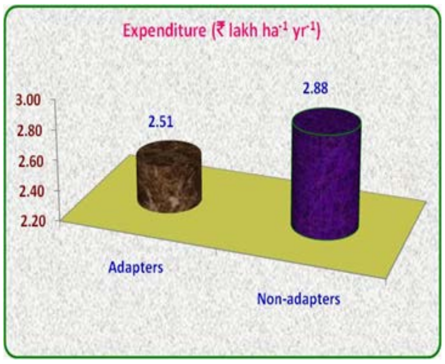


Fig 11:


Fig 12:

**Conclusions**

Worldwide agriculture is the single biggest drain on water supplies, accounting for about 69% of all use, about 23% of water meets the demands of industry & energy and just 8% goes for domestic & commercial use (Anonymous, 2002) [2]. In India, agriculture sector uses about 93% of water whereas industry and domestic & commercial sectors use 3 & 4% respectively (Rakesh kumar *et al.*, 2005). As agriculture is the major area of water consumption in our country, any one speaks of water management; the focus is only on agriculture, even if 10% of water is saved, 14 mha. will benefit additionally. Existence of vast scope for saving water in irrigation, recycling of water for domestic uses and awareness among people on water conservation are the key for water management (Palanisami, 2010) [24].

It is true that the efficiency of irrigation water and fertilizer use in mulberry cultivation is appreciated with right system and optimization of the same through adoption of recommended technologies in time. Agro-ergonomic technology adoption in agriculture brought significant improvements on quality linked productivity at significant cost reduction through combined effects on resources savings and increasing inputs use efficiency. The achievement of 219% increased net income with 3.54 benefit cost ratio to farmers those who have adopted the agro-ergonomic technologies recommended for mulberry cultivation and maintenance, the potentiality of sericulture in improving the rural economy need spread to the non-adopted farmers who have achieved only 1.7 BCR in the area and to all sericulture farmers in the southern peninsula districts of the country.

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