Project Title

Evaluation of Low Cost Drip Fertigation Systems on Yield and Quality of Mulberry Leaves

Project code

PPA-3588

Central Sericultural Research & Training Institute
Central Silk Board, Ministry of Textiles
Govt. of India, Berhampore - 742 101
Murshidabad, West Bengal.

PROFORMA - I

(To be filled by applicant)

PART - I : GENERAL INFORMATION

Sl. No.	Items	Particulars
1.	**Name of the Institute / University / Organization submitting the Project Proposal**	Central Sericultural Research & Training Institute, Central Silk Board, Ministry of Textiles, Berhampore - 742 101, Murshidad - Dist., West Bengal.
2.	**Status of the Institute (s)**	N.A.,
3.	**Name (s) and designation (s) of the Executive Authority of the Institute / University forwarding the application**	Dr. Kanika Trivedy, Director, CSR&TI., Central Silk Board, Berhampore - 742 101 (WB).
4.	**Project Title**	**Evaluation of low cost drip fertigation systems on yield and quality of mulberry leaves**
5.	**Category of the Project**	Mulberry Crop Production
6.	**Specific Area**	**Nutrient management & Drip fertigation**
7.	**Duration**	2016 - 2019
8.	**Total cost:**	3.45 lakhs
9.	**Is the project single Institutional or multi-institutional**	Single institutional
10.	If the project is multi-institutional please furnish the following	NA.,

11. Project Summary

Field experiments will be conducted in Central Sericultural Research and Training Institute, Behampore, Kolkata from 2016-19 to evaluate the low cost drip fertigation systems on yield and quality of mulberry leaves. The experiment is randomized block design with three replications. The treatments comprised of two low cost drip fertigation systems with three fertilizer levels *viz.,* 100, 75 and 50% RDF under low cost drip fertigation system and drumkit fertigation system. A control plot of surface irrigation with soil application of fertilizers will be maintained. Recommended dose of fertilizer is

336:180:112 kg NPK/ha/year. For treatments with fertigation, all the fertilizers are to be applied through low cost drip fertigation and drumkit fertigation systems. For control, all the fertilizers are to be applied as soil application as per the recommended practices. The existing mulberry garden with variety of S1635 will be selected for the experimentation. The spacing of mulberry crop is 90 cm × 90 cm for experiment-I and 60 cm × 60 cm for experiment-II. Under low cost drip fertigation system, thin wall drip tape will be used as drip lateral for to reduce the investment towards drip laterals. Under drumkit fertigation system, conventional drip lateral will be used. In the treatment plots, irrigation is to be done once in a two days based on 100% PE. For control plot, irrigation is to be done based on IW/CPE ratio method. The source of fertilizers viz., Urea (46:00:00), Di-Ammonium Phosphate (18:46:00) and Muriate of Potash (00:00:60) are to be used for fertigation. Fertigation is to be given once in seven days as per fertigation schedule for both low cost drip tape fertigation and drumkit drip fertigation system. The required quantity of N, P and K fertilizers as Urea, DAP and MOP as per the treatment were dissolved separately in bucket. Fertilizer solution is to be injected through both low cost drip tape fertigation system and drumkit drip fertigation system. Observations are to be recorded on growth, yield and quality of mulberry leaves. Estimates of total water use, water use efficiency, water productivity, fertilizer use efficiency and cost of cultivation of mulberry under low cost drip fertigation systems.

12. Objectives:

i. to evaluate the comparative performance of drip tape fertigation system and drum kit fertigation system under both 2 feet ×2 feet and 3 feet × 3 feet spacing on yield and quality of mulberry leaves

- to optimize the fertigation schedule for higher mulberry leaf productivity
- to evaluate the drip tape fertigation system and drum kit fertigation system on water use efficiency and fertilizer use efficiency of mulberry leaves
- to compute the economics of drip tape fertigation and drum kit drip fertigation system in mulberry cultivation.

PART II : PARTICULARS OF INVESTIGATORS

13. i)	Name Year of birth Sex Principal Investigator or CI Designation & Department Institute / University : Address	**Dr. Kanika Trivedy,** 1958 Female **Executive Authority,** Director, CSR&TI., CSB., Berhampore - 742 101, (WB)
ii)	Name Year of birth Sex Principal Investigator or CI Designation & Department Institute / University : Address	**Dr. R. Mahesh** 1985 Male **Principal Investigator,** Scientist-‘B’, Mori Division-I, CSR&TI., CSB., Berhampore - 742 101, (WB)
iii)	Name Year of birth Sex Principal Investigator or CI Designation & Department Institute / University : Address	**Dr. Monica Choudhari** 1957 Female **Coordinator,** Scientist-‘D’, Mori Division-I, CSR&TI., CSB., Berhampore - 742 101, (WB)
iv)	Name Year of birth Sex Principal Investigator or CI Designation & Department Institute / University : Address	**Dr. A. Vijay** 1983 Male **Co-Investigator - I** Scientist-‘B’, Mori Division-I, CSR&TI., CSB., Berhampore - 742 101, (WB)
v)	Name Year of birth Sex Principal Investigator or CI Designation & Department Institute / University : Address	**Mr. Anil Pappachan** 1989 Male **Co-Investigator -II** Scientist-‘B’, Mori Division-I, CSR&TI., CSB., Berhampore - 742 101, (WB)

14.	Expertise available with proposed investigation group / institution on the subject of the project	The PI already has adequate expertise by virtue of a) serving NETAFIM IRRIGATION INDIA LTD, the leading MNC expert in micro irrigation for 2 (two) years as Executive Agronomist. b) having done PhD in the subject which won INTERNATIONAL PLANT NUTRITION INSTITUTE, USA Scholar Award

15. LIST OF FIVE EXPERTS IN INDIA IN THE PROPOSED SUBJECT AREA

Sl. No.	Name	Designation	Address
i.	Dr. N. Chandrasekaran	Professor	Dept. of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore Tamil Nadu. Email: rasincs@yahoo.co.in
ii.	Dr. B.C. Patra	Professor	Department of Agronomy, BCKV,West Bengal Email: bikaspatra@yahoo.com
iii.	Dr. B.K Mandal	Professor	Department of Agronomy, BCKV,West Bengal
iv.	Dr. M. Pramanick	Professor	Department of Agronomy, BCKV,West Bengal Email: mahadevpramanick@yahoo.co.in
v.	Dr. P.S Bera	Professor	Department of Agronomy, BCKV,West Bengal Email: drpsb55@gmail.com

PART III : TECHNICAL DETAILS OF PROJECT

16. Project Background

Mulberry is one of the most important commercial crops grown extensively as food plant for silkworm. Mulberry (*Morus* spp.) is a perennial and high biomass producing plant, continues to grow throughout the year in tropics. The continuous production of mulberry for a long time results in gradual reduction in leaf yield and quality (Rashmi *et al.*, 2009). In India, mulberry is cultivated in 282,244 ha (Dutta, 2014) in different agro climatic conditions varying from temperate to tropical. The silkworm, *Bombyx mori* L. being monophagous insect, derives almost all the nutrients for growth and development from the mulberry leaf. It has been estimated that, nearly 70% of the silk proteins are derived from mulberry leaves. Hence, silkworms should be fed with good quality mulberry leaves in abundant quantity for the successful cocoon production (Vijaya *et al.*, 2009).

The leaf yield and quality of mulberry depends on the soil type, plant variety, and availability of plant nutrients and agro-ecological conditions, which reflects on the quality of silk production. In India, mulberry is largely cultivated for leaf production and contributes to an extent of 38.20 per cent for successful cocoon crop production (Miyashita, 1986). Sizeable area under mulberry is cultivated with flood irrigation with exclusive soil application of fertilizers. The use of flood irrigation with soil application of fertilizers lead to considerable loss of water and consequent leaching of nutrients from the soil.

So, it is essential to standardize the agro – techniques for mulberry cultivation and technological innovations are also to be exploited to achieve the objective of higher mulberry productivity and better water and nutrient use efficiency. In this regard, drip fertigation is the one of the best alternative in delivering water and nutrients to the plant. Surface irrigation methods are utilized in more than 80% of the world's irrigated lands yet the field level application efficiency is often only 40–50%. In contrast, drip irrigation may have field level application efficiencies of 70–90%, as surface runoff and deep percolation losses are minimized. Drip irrigation may allow more crops per unit water and to allow crop cultivation in areas where insufficient water exists to irrigate by surface method.

Fertigation a technique of application of both water and fertilizers through drip irrigation system during the recent years was shown to be very effective in achieving higher water and fertilizer use efficiencies. In this method, both water and fertilizer are delivered precisely in the effective crop root zone as per the crop needs and crop developmental phases. Increased growth and yield with drip irrigation has been reported in several crops and the yield increase ranged between 7 -112 per cent depending on the crops/varieties and method of irrigation. The water and fertilizer saving through drip fertigation system have been reported to be 40–70 per cent and 30–50 per cent respectively (Rekha *et al.,* 2008).

Drip fertigation is widely used for most of agricultural crops by Indian farmers to achieve higher yield. However drip fertigation system adoption involves higher initial capital cost. The laterals alone account for 60 per cent of total drip system cost (Mahesh, 2012). Low cost drip tape is another innovative technology to irrigate crops with considerable water saving and affordable for small and marginal farmers at cheaper rates. The cost of low cost drip tape is relatively very low compared to conventional inline drip lateral.

The cost of conventional inline drip lateral per running meter varies between 10-12 rupees but drip tapes cost only half of this amount. And there are possibilities to reduce 50 per cent of initial investment cost on drip laterals. Drip fertigation with drip tape is an efficient method of delivering water and nutrients nearer to the crops, providing relatively uniform, timely and precise application of water than surface irrigation methods.

"An 'appropriate technology' is usually characterized as small scale, energy efficient, environmentally sound, labor-intensive, and controlled by the local community. It must be simple enough to be maintained by the people who use it. In short, it must match the user and the need in complexity and scale and must be designed to foster self-reliance, cooperation, and responsibility (Amadei, 2004).

In this background, the present study is planned to evaluate the low cost drip tape fertigation system in comparison with drumkit drip fertigation system on yield and quality of mulberry leaves.

17. Work done

Water and nutrient are the two key inputs in mulberry production. However, their use efficiency is low and their injudicious use leads to wastage and environmental degradation. Among the various techniques, drip fertigation is the most efficient method for enhancing the input use efficiency of both water and nutrients.

Drip irrigation is the most effective way to convey directly water and nutrients to plants and not only save water but also increases yields of vegetable crops (Tiwari *et al.*, 2003). Because the drip irrigation is capable of applying small amounts of water where it is needed and to apply it with a high degree of uniformity and frequently, these features make it potentially much more efficient than other irrigation methods (Salah E. El-Hendawy *et al.*, 2008).

However, drip irrigation, in the conventional sense, has evolved to become a knowledge-intensive, technology-orientated operation, designed for larger land holdings (e.g. >4 ha), with capital costs ranging between US$ 1500 and 2500 per hectare (Phene, 1995). These conventional drip systems are unavailable, economically and technically, to the vast majority of the world's farmers who live in developing countries, have small landholdings, and limited financial resources (Postel *et al.*, 2001). The development of low-cost drip fertigation (LCDF), an irrigation method that is suited for small fields and maintains the water and nutrient savings advantages of conventional drip systems, presents the opportunity to substantially increase the economic and food security of these farmers.

Simple drip irrigation kits that are affordable and easy to assemble and maintain have been implemented successfully for irrigation of vegetable gardens of small-scale farms in several countries in sub-Saharan Africa, e.g. Kenya, Zimbabwe and South Africa (Du Plessis and Van der Stoep, 2000). Low-cost drip systems utilize gravity as the force to push water through the pipes. Normally a head of only 0.5–1 m is used for bucket kits (Sijali, 2001).

Fertilizer savings through fertigation can be to the tune of 25–50 per cent (Haynes, 1985). Fertigation reduces the nutrient loss that would normally occur with conventional methods of fertilizer application and thus, permits better availability and uptake of nutrients by the crops, leading to higher yield with high fertilizer use efficiency. Nitrogen use efficiency (NUE) for red chilli fruit production decreased with increasing N upto 240 Kg ha^{-1} (Payero *et al.*, 1990). Clark *et al.* (1991) reported that fertigation resulted in reduced water and fertilizer application as compared to those associated with conventional irrigation method.

India

Drip and sprinkler irrigation save an average of 33% water over the conventional furrow irrigation without affecting the leaf yield with improvement in leaf moisture was reported by Saratchandra (1990).

Saratchndra *et al.*, (1992) considered drip and sprinkler irrigation systems to be more efficient in economizing water use and maximizing the leaf yield of mulberry vis -a-vis furrow system. Maximum leaf yield and additional mulberry area coverage under irrigation by utilizing the water saved in drip irrigation was reported by Gopinath (1994).

Ananthakrishna *et al.* (1995) reported 48% more leaf yield and 67% water savings with drip irrigation equal to 40% CPE from open class A pan evaporimeter applied. However irrigation @ 80% of CPE value with 33% water saving under drip irrigation was found to be optimum for mulberry over conventional furrow method. Ananthakrishna *et al.,* (1995) recommended 80% Epan value of irrigation under drip scheduled alternate day for optimum leaf production in K2 mulberry.

Studies conducted in K2 by Mishra *et al.,* (1995, 1996 and 1997) revealed that the leaf yield of 36590 and 31482 kg/ha/yr with furrow irrigation at CPE value 47 and 70 mm under 3' x 3' and 2' x2' spacing respectively and 38793 and 38433 kg/ha/yr under drip irrigation at 80% and 60% of CPE value respectively with 40% water saving. In addition to water savings higher leaf moisture content, nutrient value and leaf yield were recorded.

Benchamin *et al.,* (1997) reported that drip and sprinkler irrigation save 33 % of irrigation water without loss of leaf yield and quality compared to ridges and furrow method and also found that the drip system was more efficient with 10.3 to 14.5% increased leaf yield over furrow system under any quantum of irrigation treatment. Above all the response of mulberry crop to water in terms of productivity increase by 300 to 400% when compared to rainfed condition.

Studies of Rama Kant *et al.* (1998) revealed high moisture around main root zone through limited water supply, reduced percolation loss of water; application of water-soluble fertilizers through drip saves 30 to 40 % of fertilizer and save man power requirement in mulberry cultivation.

Magadum *et al.* (2004) reported that adaptation of drip irrigation in mulberry cultivation at farmers' level in Karnataka saves a minimum 30% amount of irrigation water without affecting the leaf yield over traditional irrigation.

Nagaraj (2008) reported that drip irrigation studies in mulberry recorded about 40 percent increase in yield (75.5 tonnes/ha), 35% water saving of water and resulted 55 per cent increase in water use efficiency as compared to furrow irrigation method.

A study at Venkatanahalli, Karnataka indicated that drip irrigation showed better plant growth parameters such as number of leaves, height, number of shoots and yield. Drip irrigation has a leaf yield of 70.5 tonnes/ha as against 35 tonnes/ha in furrow irrigation. The results indicated that 61 per cent increase in number of leaves, 13.2 per cent increase in plant height, 10 per cent in number of plants, 40 per cent increase in yield from drip irrigation as compared to furrow irrigation. 35% per cent saving of water resulted in 55% increase in water use efficiency that was achived through drip irrigation as compared to furrow irrigation. The trend of these results is similsr with the findings of Rajesh Kumar (2004) in potato crops.

Drip irrigation saves maximum of 44.56% water with 15% increased leaf yield without affecting the quality of leaves, besides 25% saving in N and K fertilizers through fertigation in V1 mulberry reported by Arunadevi, (2006).

Arunadevi *et al.* (2007) reported that drip fertigation exerted favourable influence on leaf growth characters, yield and leaf quality parameters of mulberry compared to surface irrigation and soil application of fertilizers. Maximum plant height (192.40 cm), number of branches per plant (9.42), number of leaves per branch (30.78), leaf area (164.55 cm) and leaf area index (5.8) were observed under single row drip irrigation at 80% of surface irrigation level followed by paired row drip and microtube irrigations at 80% of WR of surface irrigation level. Single row drip at 80% of water requirement (WR) of surface irrigation with 100% of recommended level of fertilizers registered higher leaf yield (46,759 kg/ha/year) followed by paired row drip and microtube at 80% of WR of surface irrigation level than in micro irrigation at 60 and 40% of WR of surface irrigation level. Maximum coarse leaf moisture content (60.09%), tender leaf moisture content (72.76%), leaf nitrogen content (3.97%), leaf potassium content (2.13%), coarse leaf protein content (15.98%) and tender leaf protein content (24.30%) were observed under single row drip irrigation at 80% of WR of surface irrigation level.

Nithya *et al.* (2011) reported that drip irrigation with green manure system and biofertilizer effectively influencing the growth and yield of mulberry plants, and also it will be an economically valuable and also eco friendly.

Rajaram and Qadri (2014) reported that drip irrigation at 100% PE has registered higher mulberry leaf yield (35456.86 kg/ha/yr) which was 34.12% higher yield than furrow irrigation, Similar response recorded in growth parameters like total shoot length (1046.00 cm), number of branches (7.41) & leaves per plant (30.77), leaf area (165.61) & leaf area index (5.40) under drip irrigation at 100% PE.

Shashi Kanta (2015) reported that micro-sprinkler irrigation registered significantly higher yield (13123.35 kg/ha) over drip (11836.42 kg/ha), sub –surface (11825.89 kg/ha) and alternate furrow (10630.58 kg/ha) systems, were at par yet showing 23.45%,11.34%and 11.24%gain over alternate furrow irrigation. Drip and sub-surface systems were at par yet showing significantly higher yield over alternate furrow system

Seenappa *et al.* (2015). reported that subsurface drip irrigation recorded higher chlorophyll, relative water content, leaf yield, cocoon yield and filament length (9.74, 74.62%, 43903kg ha-1 yr^{-1},59.63 kg/100 DFLs and 748.70 m) respectively, than surface drip (8.52, 72.02%, 37894kg ha^{-1} yr^{-1}, 55.17 kg/100 DFLs and 701.87 m) and micro spray jet (8.66, 72.34%, 38354kg ha^{-1} yr^{-1}, 57. 55.23 kg/100 DFLs and 688.70 m). Among the levels of irrigation, higher level of irrigation (1.0 CPE) was found to be best in improving chlorophyll, relative water content, leaf and cocoon yield and filament length (9.91, 75.48%, 45082kg ha^{-1} yr^{-1}, 61.00 kg/100 DFLs and 756.17 m) compared to lower levels of irrigation (0.6 and 0.8 CPE). Maximum chlorophyll, relative water content, leaf yield, cocoon yield and filament length (9.16, 73.55%, 40735 kg ha^{-1} yr^{-1},57.45 kg/100 DFLs and 725.15 m) was recorded in mulching treatment than without mulching. It would be concluded that subsurface drip irrigation at 1.0 CPE with mulching increased the yield and quality of mulberry leaf and cocoon than surface drip and micro spray jet irrigation. Hence, subsurface drip irrigation may be more appropriate to attain higher quality and quantity in mulberry leaf and cocoon production in Eastern Dry Zone (EDZ) of Karnataka.

Nagaraj (2008) reported that considering the profit wise returns, the irrigation given through drip was profitable (return per rupee investment is 4.11) as compared to furrow irrigation system (return per rupee investment is 2.61). The drip system was designed and installed as per standard practices using approved quality components and costed about Rs.47000 to 49000 per ha for mulberry.

Higher gross returns Rs. 70500/ha, Net returns Rs 56697/ha and B:C ratio: 4.11 was obtained under mulberry cultivation under drip irrigation compared to furrow irrigation (Gross returns Rs. 42000/ha, Net returns Rs.: 30357/ha and B:C ratio: 2.61 reported by Nagaraj (2008)

The cost benefit ratio in drip and furrow irrigation in mulberry of 1.64 and 2.37 respectively was reported by Muralihara *et al.*(1994). Mishra and Chaudhury (1997) reported that the cost benefit ratio of the technology is 1:1.60. Under laboratory conditions, the leaf yield in drip-irrigated plots was observed higher (37.14 MT/ha/yr) as compared to furrow-irrigated plots with narrow frequency of irrigation (35.47 MT/ha/yr).

The cultivation of cauliflower is profitable after the first harvest with both low-cost drip fertigation and hand watering irrigation methods (Stefanie von Westarp *et al.,* 2003). Maisiri *et al.* (2005) reported that low cost drip with fertigation had the highest gross margin of US$15 levels followed by low cost drip with granular fertilizer at US$11 then conventional with granular fertilizer at US$10.60 and the least gross margin was from low cost drip with no fertilizer at US$8. The low cost drip system with granular fertilizer gave the highest gross margin to total variable cost (GM/TVC) ratio of 2.47. This was followed by low cost drip with fertigation with a GM/TVC ratio of 2.37 and the least ratio was found in low cost drip with no fertilizer treatment.

Abroad

Paul Polak *et al.* (1999) reported that the drum kit uses a 200 -liter drum instead of a bucket, and uses five lateral lines to irrigate a 125 square meter plot for a cost of $25. It can be expanded in 125 square meter increments at a cost of $14 for each expansion unit.

Fertilization plays a very important role for enhancing mulberry productivity and improving soil fertility. Local research suggests that proper nutrient management can increase mulberry leaf yields by 35% and can also improve leaf qualities (Tan *et al.,* 1997; Wang *et al.,* 2001).

Won Chu Lee (1992) reported that fertigation and fertigation with extra fertilizer increased mulberry leaf yield by 22%, respectively compared with conventional. Fertigation increased leaf water content, P_2O_5, K_2O and CaO in leaves, suggested improving mulberry leaf quality in fall. Fertigation increased available P_2O_5 content in the sub-soil. More root distribution showed at the sub-soil in fertigation. Stefanie von Westarp *et al.* (2004) reported that lowcost drip irrigation and hand watering are both viable options to increase food production in water scarce, small-scale farming in Nepal, however, long-term economic and labour benefits are greater under LCDI. LCDI is more advantageous than Hand Watering and Conventional Drip Irrigation in terms of long-term profitability and labour savings.

Maisiri *et al.* (2005) reported that low cost drip with fertigation had the highest water productivity at 10.8 kg/m^3 and conventional surface irrigation had the lowest at 2.4 kg/m^3 in vegetables. Low cost drip systems achieved water saving of more than 50% compared to surface irrigation systems. It was recommended that low cost technologies should be used in conjunction with good water and nutrient management if higher water and crop productivity are to be realized than surface irrigation systems.

Drip systems proved to be labour intensive especially in filling of the drum compared to conventional surface irrigation system. All the farmers found the drip kits easy to operate. All the respondents were able to grow vegetables enough for household consumption from the drip kits, however the surplus produce was not enough for them to meet the cost of the following season inputs reported by Maisiri *et al.* (2005).

Patel *et al.* (2015) reported that the gravity drip irrigation can play a vital role in bringing the small pockets of land holding under irrigation in a cost effective manner and increase the cropping intensity in the region. The use low pressure rating pipe for operating under low gravity heads can reduce cost of micro irrigation system. The use of low head gravity drip system saves cost up to 26 percent.

Other crops

Narayanan *et al.* (1994) conducted an experiment to evaluate the economic benefits of drip irrigation in sweet pepper and reported that maximum gross return was obtained with drip irrigation compared to furrow irrigation. Sivanappan (1996) reported that an extra income of Rs. 49,280 ha-1 could be obtained under drip irrigation in tomato over surface irrigation and the payback period of drip system cost was only six months. Asokaraja (1998) recorded higher benefit cost ratio of 9.89 due to drip irrigation than surface irrigation (5.44) in tomato.

Khan *et al.* (1999) found that drip fertigation with 100 per cent water soluble fertilizers in potato has recorded higher net profit of Rs. 38,742 ha-1 when compared to drip fertigation with 100 per cent normal fertilizer (Rs. 33,604 ha^{-1}) and furrow irrigation with 100 per cent normal fertilizer (Rs. 32,583 ha-1).

In experiment conducted in brinjal by using irrigation and different levels of fertigation (50, 75, 100 and 125% recommended dose of solid soluble fertilizer) was found that micro jet irrigation with 100 per cent recommended dose of solid soluble fertilizer recorded highest number of fruits per plant (433.13), weight of fruit (44.18g) and fruit yield (41.51 tonnes per hectare) (Shinde *et al.*, 2002).

Patel and Rajput (2005) reported in tomato that fertilizer application at 100 per cent recommended dose through fertigation recorded an increase in yield of 25.21per cent. Neelam and Rajput (2005) reported in onion that the highest yield was recorded in daily fertigation (29.2t/ha) followed by alternate day fertigation (28t/ha) while the lowest yield was recorded in monthly fertigation (22.4t/ha). Ananta (2006) reported that the highest fruit yield of tomato was noticed when nitrogen was supplied in 80 or 10 split doses with 100 per cent ET through drip irrigation.

In okra nitrogen fertigation with 100 per cent recommended dose gave higher pod yield of 16.9 tonnes per hectare (Patel *et al.*, 2009). Brahma *et al.* (2010) revealed that drip irrigation at 100 per cent evaporation replenishment along with supplementation of 100 per cent recommended N and K though fertigation, the pooled data averaged over the three years revealed that fertigation with 100 per cent recommended N and K recorded 61.09 per cent increased yield over conventional fertilization.

Sankaranarayanan *et al.* (2011) reported that moderately higher yield (2620 kg/ha) with all the positive effects (of drip) along with lower cultivation cost (Rs 27,190/ha) were incurred in poly tube drip system further led to higher net return (Rs 38,310/ha) and BCR (2.41). Thus, the trial focused on the suitability and viability of the use of low cost polytube drip for an efficient on farm irrigation scheduling in Bt cotton. Even though, the existing drip system had higher growth, yield attributes and seed cotton yield (2705kg/ha) but higher per annum irrigation cost (Rs. 12,594/ha) incurred, ultimately leads to increased cost of cultivation (Rs. 32,865/ha) thus reduced the net return (Rs.34,760/ha) and benefit cost ratio (2.06) of the system.

Drip irrigation at 100 per cent WRc with 100 per cent RDF registered the highest additional net income of Rs. 1,23,679 and BCR of 3.30 in chilli which was closely followed by drip irrigation at 80 per cent WRc with 100 per cent RDF registering an additional net income of Rs. 1,19,488 and BCR of 3.23 over surface irrigation (Selvakumar, 2006). Imamsaheb *et al.* (2011) reported fertigation level 100 per cent recommended NPK among with genotypes PTR-6 resulted in highest yield (63.78 t/ha) and net income (Rs.1,14,470.91/ha), gross income (Rs.1,59,450/ha) and B: C ratio of 3.22.

18. Work plan

18.1. Technical details

18.2. Experiment title: Evaluation of low cost drip fertigation systems on yield and quality of mulberry leaves

18.3. Objectives

ii. to evaluate the comparative performance of drip tape fertigation system and drum kit fertigation system under both 2 feet ×2 feet and 3 feet × 3 feet spacing on yield and quality of mulberry leaves

iii. to optimize the fertigation schedule for higher mulberry leaf productivity

iv. to evaluate the drip tape fertigation system and drum kit fertigation system on water use efficiency and fertilizer use efficiency of mulberry leaves

v. to compute the economics of drip tape fertigation and drum kit drip fertigation system in mulberry cultivation

18.4. Experimental details

Crop	:	Mulberry	Treatments	:	7
Variety (Main)	:	S-1635	Replications	:	3
Spacing	:	2’ x 2 & 3’ x 3’	Experiment design	:	RBD
Duration	:	3 Years	No. of crops/year	:	5

1. Experiment-I with 2 feet x 2 feet spacing
2. Experiment-II with 3 feet x 3 feet spacing

18.5. Treatment details

T1 : Fertigation at 100% RDF with low cost drip tape irrigation system

T2 : Fertigation at 75% RDF with low cost drip tape irrigation system

T3 : Fertigation at 50% RDF with low cost drip tape irrigation system

T4 : Fertigation at 100% RDF with drum kit drip irrigation system

T5 : Fertigation at 75% RDF with drum kit drip irrigation system

T6 : Fertigation at 50% RDF with drum kit drip irrigation system

T7 : Surface irrigation with soil application of 100% RDF

Recommended dose of fertilizers: 336:180:112 kg NPK/ha/year

Note: For treatments (T1-T6), all the fertilizers are to be applied through low cost drip fertigation system as per the fertigation schedule given in Table 1-3. For treatment (T7), all the fertilizers are to be applied as soil application as per the recommended practices.

18.6. Drip fertigation design details

S.No	Particulars	Low cost Drip Fertigation System	Drumkit Drip Fertigation System
1	Type of system	Pressurized drip system	Gravitation force drip system
2	Lateral to lateral length	2 feet & 3 feet	2 feet & 3 feet
3	Fertigation	Venturi	Fertilizer solution are mixed with tank water

18.7. Irrigation management

In the treatment plots, irrigation is to be done once in a two days based on 100% PE. For control plot, irrigation is to be done based on IW/CPE ratio method.

18.8. Nutrient management

The source of fertilizers *viz.,* Urea (46:00:00), Di Ammonium Phosphate (18:46:00) and Muriate of Potash (00:00:60) are to be used for fertigation. Fertigation is to be given once in seven days as per below fertigation schedule for both low cost drip tape fertigation and drumkit fertigation system. The required quantity of N, P and K fertilizers as Urea, DAP and MOP as per the treatment were dissolved separately in bucket. Required quantity of fertilizer solution is to be injected through both low cost drip tape fertigation system and drumkit drip fertigation system.

Table 1. Drip fertigation schedule for 100% RDF (27.21: 14.57:9.07 NP K kg/ac/crop)

Stage	No of fertigation	Source of fertilizers	Qty (kg/ac /crop)	Nutrient availability (Kg)			Individual Fertigation (kg/ac/crop)
				N	P	K	
15 & 22 DAP	2	DAP (18:46:00)	23.77	4.28	10.93	0.00	11.88
		Urea (46:00:00)	5.47	2.51	0.00	0.00	2.73
		MOP (00:00:60)	3.74	0.00	0.00	2.25	1.87
Sub Total				**6.79**	**10.93**	**2.25**	
29 & 36 DAP	2	DAP (18:46:00)	7.98	1.44	3.67	0.00	3.98
		Urea (46:00:00)	26.44	12.16	0.00	0.00	13.21
		MOP (00:00:60)	3.74	0.00	0.00	2.25	1.87
Sub Total				**13.60**	**3.67**	**2.25**	
41 & 49 DAP	2	Urea (46:00:00)	14.78	6.80	0.00	0.00	7.38
		MOP (00:00:60)	7.57	0.00	0.00	4.54	3.78
Sub Total				**6.80**	**0.00**	**4.54**	
Grand Total				**27.19**	**14.60**	**9.04**	

*DAP- days after pruning

Table 2. Drip fertigation schedule for 75% RDF (20.40: 10.93 : 6.80 NP K kg/ac/crop)

Stage	No of fertigation	Source of fertilizers	Qty (kg/ac /crop)	Nutrient availability (Kg)			Individual Fertigation (kg/ac/crop)
				N	P	K	
15 & 22 DAP	2	DAP (18:46:00)	17.82	3.21	8.20	0.00	8.91
		Urea (46:00:00)	4.10	1.89	0.00	0.00	2.05
		MOP (00:00:60)	2.81	0.00	0.00	1.69	1.40
Sub Total				**5.09**	**8.20**	**1.69**	
29 & 36 DAP	2	DAP (18:46:00)	5.98	1.08	2.75	0.00	2.99
		Urea (46:00:00)	19.83	9.12	0.00	0.00	9.91
		MOP (00:00:60)	2.81	0.00	0.00	1.69	1.40
Sub Total				**10.20**	**2.75**	**1.69**	
41 & 49 DAP	2	Urea (46:00:00)	11.08	5.10	0.00	0.00	5.54
		MOP (00:00:60)	5.68	0.00	0.00	3.41	2.83
Sub Total				**5.10**	**0.00**	**3.41**	
Grand Total				**20.39**	**10.95**	**6.78**	

Table 3. Drip fertigation schedule for 50% RDF (13.60: 7.29 : 4.53 NP K kg/ac/crop)

Stage	No of fertigation	Source of fertilizers	Qty (kg/ac/crop)	Nutrient availability (Kg)			Individual Fertigation (kg/ac/crop)
				N	P	K	
15 & 22 DAP	2	DAP (18:46:00)	11.88	2.14	5.47	0.00	5.94
		Urea (46:00:00)	2.73	1.26	0.00	0.00	1.36
		MOP (00:00:60)	1.87	0.00	0.00	1.12	0.93
			Sub Total	**3.40**	**5.47**	**1.12**	
29 & 36 DAP	2	DAP (18:46:00)	3.99	0.72	1.83	0.00	1.99
		Urea (46:00:00)	13.22	6.08	0.00	0.00	6.60
		MOP (00:00:60)	1.87	0.00	0.00	1.12	0.93
			Sub Total	**6.80**	**1.83**	**1.12**	
41 & 49 DAP	2	Urea (46:00:00)	7.39	3.40	0.00	0.00	3.69
		MOP (00:00:60)	3.79	0.00	0.00	2.27	1.89
			Sub Total	**3.40**	**0.00**	**2.27**	
			Grand Total	**13.59**	**7.30**	**4.52**	

*DAP- days after pruning

18.9. Morphometric observation to be recorded:

a) **Irrigation water quality**
- pH & Electrical Conductivity (dS/m)
- Sodium Adsorption ratio
- Toxic ions (Chloride, Sulphate and Boron)

b) **Growth parameters :**
- Number of shoots/plant
- Shoot length (cm)
- Number of leaves/Shoot
- Total leaf weight/plant (kg)
- Total shoot weight/plant (kg)

c) **Leaf quality parameters :**
- Leaf Moisture (%)
- Protein content (mg/g of green leaf)
- Total Sugar content in leaf (mg/g of green leaf)

d) **Water and nutrient use studies**
- Irrigation water requirement (mm ha^{-1})
- Water saving (%)
- Water use efficiency (kg ha^{-1} mm^{-1})
- Water productivity (lit/kg of mulberry leaves)
- Nutrient use efficiency (kg/kg of NPK applied)

e) **Soil Chemical Analysis**
- pH, & Electrical conductivity (dS/m)
- NO_3/ NH_4 ratio
- Nutrient mobility in the soil

f) Economics

- Cost of cultivation of mulberry crop per hectare per year with low cost drip fertigation system
- Cost of cultivation of mulberry crop per hectare per year with drum kit drip fertigation system

19. Proprietary / patented items, if any, expected to be used for this project : No

20. Suggested plan of action for utilization of the expected outcome from the project

- Potential productivity of the mulberry tested with low cost drip fertigation and drumkit drip fertigation system.
- Optimized drip fertigation schedule to exploit full potential of mulberry leaves productivity will be determined.
- Water and fertilizer saving technology will be achieved and this will leads to reduce the environmental pollution.
- Affordable drip fertigation technology will be developed for adoption of drip technology by small and marginal farmers of eastern and north eastern regions of India.

21. Organization of Work Elements

Sl. No	Name of the scientist	Work distribution	Work to be done
1.	Dr. Monica Chaudhuri,	-	Co ordinating all activities for successful conduct of experiments as per schedule and milestone.
2.	Dr. R. Mahesh, PI	60%	Arrangements of all inputs, drip installation and maintenance of experiment plots as per schedule, Quality of irrigation water analysis, Imposing treatments in the experimental plots and collection of growth, yield and water use studies data, and final report preparation and submission
3.	Dr. A. Vijay, CI-1	20%	Soil chemical analysis
4.	Sri. Anil Pappachan, CI-2	20%	Leaf quality analysis

21. Schedule of activities / milestones:

S.No	Milestone/Activity	Expected Date of	
		Starting	Completion
1.	Quality of irrigation water analysis, Initial soil chemical analysis Low cost drip fertigation system installation	Oct, 2016	Dec, 2016
2.	1st crop –First year	Jan, 2017	Mar, 2017
3.	2nd crop –First year	Mar, 2017	May, 2017
4.	3rd crop –First year	Jun, 2017	Aug, 2017
5.	4th crop –First year	Aug, 2017	Oct, 2017
6.	5th crop –First year	Oct, 2017	Dec, 2017
7.	1st crop –Second year	Jan, 2018	Mar, 2018
8.	2nd crop – Second year	Mar, 2018	May, 2018
9.	3rd crop – Second year	Jun, 2018	Aug, 2018
10.	4th crop – Second year	Aug, 2018	Oct, 2018
11.	5th crop – Second year	Oct, 2018	Dec, 2018
12.	Final report preparation and Submission	Jan, 2019	Mar, 2019

22. Project Implementing Agency / Agencies :

Name of the Agency	Address of the Agency	Proposed Research Aspects	Proposed Amount (lakhs)	Cost Sharing %
Central Silk Board.,	CSB Complex, BTM Layout., Madivala, Banagalore - 560 068.	Mulberry Crop Productivity	3.45	Full

23. Budget for two years (2016-2018)

S. No.	Particulars	2016-17 (lakhs)	2017-18 (lakhs)	Total (lakhs)
I.	**Drip systems**			
a.	Low cost drip fertigation systems installation Experiment-I: 2’×2’ & Experiment-II: 3’×3’	1.20	-	1.20
II	**Recurring contingencies**			
a.	Cultivation expenses (Mulberry garden maintenance)	0.40	0.40	0.80
b.	Travelling Allowance	0.25	0.25	0.50
c.	Miscellaneous	0.15	0.15	0.30
d.	Laboratory chemicals	0.15	0.15	0.30
e.	Portable digital weighing	0.20	-	0.20
f.	Report preparation and submission of final report	-	0.15	0.15
	Total	**2.35**	**1.10**	**3.45**

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PART V : DECLARATION / CERTIFICATION

It is certified that

a. The research work proposed in the project does not in any way duplicate the work already done or being carried out elsewhere on the subject.
b. The same project has not been submitted to any other agencies for financial support.
c. The emoluments for the manpower proposed are those admissible to persons of corresponding status employed in the institute / university or as per the Ministry of science & technology guidelines (Annexure – III).
d. Necessary provision for the project will be made in the Institute in anticipation of the sanction of the scheme.
e. If the project involves the utilization of genetically engineered organism, it is agreed that we will ensure that an application will be submitted through our institutional bio-safety committee and we will declare that while conducting experiments, the bio-safety committee we will declare that while conducting experiments, the bio-safety guidelines of the Department of Biotechnology would be followed in toto.
f. If the project involves field trials / experiments / exchange of specimens etc. we will ensure that ethical clearances would be taken from the concerned ethical committees / competent authorities and the same would be conveyed to the Department of Biotechnology before implementing the project.
g. It is agreed by us that any research outcome or intellectual property right(s) on the invention (s) arising out of the Project shall be taken in accordance with the instructions issued with the approval of the Ministry of Finance. Department of Expenditure, as contained in annex. - V.
h. We agree to accept the terms and conditions as enclosed in Annexure - IV. The same is signed and enclosed.
i. The Institute agrees that the equipment, the basic facilities and such other administrative facilities as per terms and conditions of the grant will be extended to investigators throughout the duration of the project.
j. The Institute assumes to undertake the financial and other management responsibilities of the project.

1. Signature of Executive Authority of Institute with Seal
   Date :

2. Signature of Coordinator
   Date :

3. Signature of Principal Investigator
   Date :

4. Signature of Co- Investigator -I
   Date :

5. Signature of Co- Investigator-II
   Date :

PART VI: BIODATA OF PROJECT CO-ORDINATOR / PRINCIPAL INVESTIGATOR / CO-INVESTIGATOR (S)

PRINCIPAL INVESTIGATOR

1. Full Name (In Block letters) : **Dr. R. Mahesh**
2. Designation : Scientist-B
3. Department/Institute/University
   Address for communication : Agro-Physio-Farm management,
   Central Sericultural Research & Training Institute, ,
   Berhampore - 742 101,
   Dist. Murshidabad, West Bengal
4. Date of birth : 25.05.1985
5. Sex : Male
6. Education (Post Graduation onwards & Professional Career):

Name of the University	Degree Passed	Year of Passing	Subject taken with specialization	Class/ Division
Tamil Nadu Agricultural University	M.Sc (Ag)	2009	Agriculture (Agronomy)	1st
Tamil Nadu Agricultural University	Ph.D (Ag)	2016	Agriculture (Agronomy)	1st

Memberships/fellowship: -

1. Direct Member (Young Professional) of International Commission on Irrigation and Drainage (Receipt No: ICID/DM/8)
2. Member of American Society of Agronomy
3. Life Member of Indian Water Resources Society
4. Life Member of Trends in Biosciences
5. Life member of Valarum Velanmai (Monthly Magazine by TNAU)

Patents: (Not required for in-house personnel)

Publications (Number only):

Book	:	1nos
Technical bulletin	:	4nos
National article published	:	3nos
Articles in the proceeding of national conferences	:	5nos
Book chapters	:	5nos
Training attended	:	1nos
Leaflets	:	1nos
International Magazines	:	2nos
Conferences attended (National)	:	7nos
Abstract published	:	6nos
Newspaper cuttings published	:	3nos

CO- INVESTIGATOR -I

1. Full Name (in Block letters) : **Dr. V. VIJAY**

2. Designation : Scientist-B

3. Department/Institute/University : Mulberry Pathology Section,
Central Sericultural Research and Training Institute,
Berhampore (WB)

4. Address for Communication : Mulberry Pathology Section,
Central Sericultural Research and Training Institute,
Central Silk Board, MoT, Govt. of India,
Berhampore-742101, Murshidabad (D), West Bengal

5. Date of Birth : 10.04.1983

6. Sex : Male

7. Education (Post-Graduation onwards & Professional Career):

S.No.	Institution/Place	Degree Awarded	Year	Field of Study
1.	The American College, Madurai Kamaraj University, Madurai (TN)	M.Sc.	2006	Immunology & Microbiology
2.	Bharathiar University, Coimbatore (TN)	Ph.D.	2015	Biotechnology

8. Honors/Awards [Not required for in-house personnel]: Not applicable

9. Positions held/Research experience in various institutions [Not required for in-house personnel]: NA

10. Memberships/ Fellowships [Not required for in-house personnel]: NA

11. Patents [Not required for in-house personnel]: NA

12. Publications (Numbers only):
Books: 0 Research Papers: 0 Reports: 0 General articles: 0 Patents: 0
Others: Proceedings – 1; Abstract – 1; GenBank submissions – 5

13. Project (s) submitted/ being pursued/ carried out by investigator: 01

14. Highlights of outcome/ progress of the project (s) handled during the past 10 years, their outcome and utilization (in 200 words): Nil

CO- INVESTIGATOR-II

1. Full Name (in Block letters) : **Mr. Anil Pappachan**
2. Designation : Scientist-B
3. Department/Institute/University

   Address for communication : Agro-Physio-Farm mangement,
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   West Bengal
4. Date of birth : 02.01.1989
5. Sex : Male
6. Education (Post Graduation onwards & Professional Career):

Name of the University	**Degree Passed**	**Year of Passing**	**Subject taken with specialization**	**Class/ Division**
ANGRAU, Hyderabad	M.Sc (Ag)	2013	Agriculture (Plant Pathology)/ICAR JRF	1st
UAS, GKVK, Bangalore	Ph.D (Ag)	Yet to be completed	Agriculture (Plant Pathology)/ICAR SRF	-

Memberships/fellowship: -

Patents: (Not required for in-house personnel)

Publications (Number only):

Books: -Nil

Research Papers: 6 Full papers

Abstract: 1