Ready reckoners for In-house Projects as on June, 2022

Name of the Projects	Project Leader	Past work	Deliverables	Status	Date of start/ completion
Soils					
1. Integrated nutrient management in tea (Phase I & **II**) **(New Proposal Extension)**	Dr. I. K. Phukan & Dr. J. Dutta	Experiment carried out at Tocklai during 2002-2003 showed that that replacement of 33% of inorganic fertilizers by 5t vermicompost maintained yield at par with 100% inorganic fertilizer (150 kg N) Saikia *et al*. (2005). Saffique *et al.* (2013) reported that 25% replacement of inorganic nitrogen by either 6 t vermicompost or by mixed bio-fertilizer maintained yield and leaf nitrogen on at par with control (100% RDF) This experiment was carried out at commercial tea estate at South Bank.Pot culture expt carried out during 1997-98 indicated that 20 kg N /ha as urea and 80 kg N/ha as organic manure recorded highest total biomass following one year growth	Development of cost effective technology for integrated nutrient management in tea to reduce the load of chemical fertilizers and sustain soil and tea productivity.	**July – September 2016 (Q3)** • Weekly green leaf yield was recorded. Crop yield data varied from 5.73 to 8.13 kg among the various treatments in Borbetta TE and from 8.38 to 11.98 kg in Bhagatpore TE, Nagrakata • Soil samples collected from Bhagatpore TE were analyzed for pH and org C. Soil pH and organic C varied from 4.39 to 4.99 and 0.99 to 1.23% respectively under different treatments. • Last split doses of .fertilizer (NPK) was applied. **October– December 2016 (Q4)** • Weekly green leaf yield of the experimental plots were recorded in both the experimental site. • Collected soil samples were analyzed for available-N, NH_4-N and NO_3-N content. In Bhagatpore TE, av. N varied from 92 to 118 mg/kg. Soil NH_4-N and NO_3-N content was found to vary from 32-52 mg/kg and 15-28 mg/kg respectively under various treatments. • Soil samples collected from Borbhetta trial was estimated for soil organic C. Org C varied from1.11 to 1.21% under various treatments. **January – March 2017 (Q1)** • 27nos of leaf samples, collected in the month of November 2016, were analyzed for total N	Date of start (2013) Likely date of completion (2018) Likely date of completion by 2020 (In mature tea) Experiment on Young tea is stopped.

				content. Total N in shoot varied from 4.70% to 4.87%. • Plants in the experiment on young tea received FFP (2) during January-2017. Weight of pruning litters recorded under RDF treated plot was at par with the INM treatment comprising 75% of YTD in combination with 25% of consortium of biofertilizer. **April-June-2017 (Q2)** Manuring in both the experiments (Bhagatpore + Borbheta) for the year 2017 was imposed in the experimental plots. At the time of manuring, soil samples were collected for the estimation of soil physical, chemical and microbiological parameters. In the experiment on young tea org C and av. P varied from 0.99 to 1.26 % and 16 to 33 mg/kg under different treatments. All the integrated treatments maintained significantly higher org C and av. P (1.20-1.26% and 24-34 mg/kg) respectively over RDF (Only YTD; org C: 1.14% and av. P_2O_5: 19 mg/kg). Weekly green crop data was recorded in the experimental plots in both the experiments. **<u>July-Sept-2017 (Q3)</u>** 2nd split of manuring in both the experiments (Bhogotpur + Borbheta) was applied in the experimental plots during August. Weekly green leaf yield was recorded. In the young tea experiment, weekly average green leaf yield of tea varied from 15.5 kg/plot (25% YTD + consortium BF) to 23.2	

				kg/plot (75% YTD + Consortium BF). Plots receiving only YTD produced 17.6 kg/plot. In the experiment at Bhogotpur, Weekly average green leaf yield varied from 25.6-33.6 kg/plot under different treatments. The treatment consisting of 75% of RDF in combination with 6 kg biofertilizer mixed with 1 mt VC indicated the highest yield (33.6 kg/plot). Org C under different treatments varied from 2.29 to 2.50%. Barring 50% RDF plus 50% castor cake (N-equivalence) treatment, all the INM treatments maintained significantly higher org C (2.40-2.50%) over 100% inorganic (2.29%). **Oct-Dec-2017 (Q4)** • Weekly green leaf yield was recorded up to 2nd week of Dec in both the INM experiment on young and mature tea at Borbheta and Bhogotpur TE respectively. In the young tea yield of green leaf varied from 24.1 kg/plot (only bio-fertilizer treated plot) to 38 kg/plot (75% YTD + Consortium bio-fertilizer). Plots receiving recommended doses of YTD produced 33 kg green leaf/plot. Plants received UP during 2018. • In the Bhogotpur experiment, average green leaf yield of tea varied from 56.2 kg/plot to 65.1 kg/plot under different integrated treatments. Plots receiving recommended doses of fertilizer (120 kg N/ha) produced 60.3 kg /plot. Plants received LP during 2018. **Jan-March 2018(Q1)** • Soil available phosphate under various treatments in the young tea experiment varied from 21 to 36 mg/kg. Plots receiving 50-75% of YTD plus consortium of bio-fertilizer showed higher	

				available phosphate (33-35 mg/kg) over the plot that received 100% YTD (24 mg/kg). • Population of beneficial microorganisms viz., Azospirilum, Azotobacter and PSB under various treatments in the INM experiment on young tea were found to be much higher under all the integrated treatments over 100% YTD. • Continuing **April-June-2018 (Q2)** Manuring, in the experimental plots, has been done in both the experiments during 1st week of May. Weekly green crop yield data was recorded in the experimental plots in both the experiments. Soil samples were collected before imposition of treatments for analysis of physico-chemical and microbiological analysis. **July-September-2018 (Q3)** In mature tea at Bgogotpur TE , weekly green leaf weight in the experimental plots was recorded. The mean yield of green shoots recorded till date varied from 41.6 (50% RDF + 50% of Castor cake in N equivalence) to 44.8 kg/plot (75% RDF + 6 kg BF in 1t vermicompost/castore cake). Plot receiving recommended quantity of N produced 43.2 kg/plot. 2nd split doses of treatments were applied during September. **October-December-2018 (Q4)** Weekly green crop yield data was recorded in the experimental plots in both the experiments.	

				<u>January-March-2019 (Q1)</u> **The experiment is terminated.** **<u>April-June-2019 (Qr 2)</u>** Experiment on mature tea at Bhogotpur tea estate has been stopped w.e.f Dec-2018 However, experiment on young tea at Borbheta experimental field has been continued with little modification of treatments. As the plants have crossed the age of 5 years (youngish mature), the experimental plots received N,P,K through broad casting. In addition to 100% recommended doses of fertilizer (N_{100}, P_{30} and K_{100} kg/ha), 25-50% of NPK was replaced by consortium of biofertilizer viz., N-Fixer, P-solubilizer and K-solubilizer under INM treatments. Treatments were imposed in May-2019. **<u>July-Aug (Qr 3)</u>** Weekly crop record was monitored. Soil samples were collected for estimation of soil chemical parameters. <u>Oct-Dec-2019 (Q4)</u> Soil samples were collected during Nov-2019 and estimated for soil chemical parameters. Soil pH, org. C, av P_2O_5 and av. K_2O in INM experiment under various treatments varied from 4.67 to 5.01, 0.99 to 1.09%, 20-32 mg/kg and 74 to 124 mg/kg respectively under different treatments. Weekly green leaf yield of tea was recorded up to Nov-2019.	**2nd Phase on "INM" in Mature tea.. Likely date of completion (Dec-2022)**

				Cold weather cultural activities were carried out during Dec-2019. **<u>March-June-2020(Q1)</u>** Weekly plot wise green leaf yield of tea, was recorded during April-June. 75% NPK (RDF) + consortium of BF (*Azospirilum, Azotobacter, PSB/PSF and KSB*) was at par with 100% RDF. During 2019, 100 % recommended doses of NPK ($N:P_2O_5:K_2O$: 100 kg: 30 kg:100 kg/ha) produced non-significant higher yield of tea (1424 KMTH) over 75% of recommended doses of NPK in combination with consortium of N-fixing, P-solubilizing and K-solubilizing biofertilizer (1295-1340 KMTH). On the other hand, 50% replacement of recommended doses of NPK (RDF) by the said biofertilizer consortium produced significantly lower yield of tea(1130-1170 KMTH) over 100% RDF. Soil samples were collected from the experimental plots during April-2020 and estimated for different soil parameters. Plot receiving 100% RDF maintained significantly higher av. K_2O (124 mg/kg) over all the INM treatments (63-85 mg/kg). INM treatments with 75% NPK in recommended doses + consortium of Azospirilum, Azotobacter, phosphate and potash solubilizing microorganisms @ 200 L /ha maintained significantly higher soil av. P_2O_5 (32 mg/kg) over 100% RDF (21 mg/kg). **July-September-2020(Q2)**	

				Weekly green leaf yield of tea was recorded in the experimental plots. Yield of tea recorded till Sept-2020, indicated that 75% recommended doses of NPK (RNPK) + biofertilizer consortium (*Azospirilum, Azotobacter, PSF (or PSB) and KSB*) @ 100-200 L /ha produced non-significantly higher yield (1030-1047 KMTH) over 100% RNPK (991 KMTH). N content in shoot under these two integrated treatments were significantly higher (4.25-4.32%) over 100% RNPK (3.82%) 2nd split doses of fertilizer was applied during 1st week of September. **Oct-Dec-2020 (Q3)** 75% recommended doses of NPK (RNPK) + biofertilizer consortium (*Azospirilum, Azotobacter, PSF (or PSB) and KSB*) @ 100-200 L /ha produced yield of tea at par with 100% RNPK(75% RNPK: 1475-1500 KMTH) over 100% RNPK (1496 KMTH). Plants will receive LP during end Dec-2020. **Jan-March-2021(Q4)** Plants under INM experiment at Borbheta received LP during Dec-2020. Pruning litter (PL) weight under different treatments varied from 50 to 60 kg/plot. 75% of recommended quantity of NPK in combination with consortium of biofertilizer produced yield of PL (55-58 kg/plot) at par with 100% NPK treated plot (60 kg/plot). Soil samples were collected from the experimental plots at the time of pruning for the estimation of soil	

				physical, chemical and microbiological parameters. Results indicated that 25% recommended doses of NPK in combination with consortium of biofertilizer significantly increased soil organic C over 100% NPK treatment. **April-June_2021 (Q1)** Soil samples, collected after 1 month of retaining of pruning litters *in situ* for the estimation of chemical parameters. Results indicated that under different treatments, 13 to 19% increase of org C, 6-8% decrease on pH, 10-11% increase in soil av P_2O_5 and 7.6 to 14% increase in soil av. K_2O over the status that was recorded at the time of pruning. Weight of green leaf in the experimental plots under different treatments for the year 2021 was recorded during the period under review. **July-September-2021 (Q2)** Soil samples were collected from respective treatments before imposition of second dose of fertilizers. The soil parameters were analyzed for soil pH and organic carbon, available potash etc. The analysis results showed that the soil pH and organic carbon percent were varied from 4.61 to 4.86 and 1.15% to 1.22% and 73 to 121 ppm, respectively. Weekly green leaf weight also recorded. **October-December-2021 (Q3)** Recording of weekly green leaf was continued. The analysis of soil parameters also undertaken. The analysis result indicated that the content of available nitrogen and phosphorus were varied from 109 to 129 ppm and 21 to 34 ppm respectively. Analysis of microbial biomass carbon initiated and result varied from 99 to 202 ppm under different treatments. The fractions of soil nitrogen and exchange acidity, exchangeable Al, extractable acidity analysis also initiated	

				and analysis under progress. Effect of treatments on yield showed that the yield increased in the all the INM treated plots over control. However, treatment receiving 75% NPK + consortium of Biofertilizer (200 L/ha) produced highest yield. Soil samples were collected from respective treatments during end of season for evaluation soil properties. **January-March-2022 (Q4)** Plants in the experiment on mature tea were kept upruned. The level of skiff (LOS) operation was undertaken during February, 2022. Pre-treatment soil samples were collected during March, 2022. **April –June 2022 (Q2)** Weekly plucking operation was done and recorded the yield. The treatments were imposed during month of April, 2022. To evaluate the important physico-chemical properties of soil, the soil samples were collected before imposition of treatments and the pre-treatment soil sample analysis process is under progress	
2. Effect of Biochar & biochar based organic manure on the growth and yield of young	Dr I.K.Phukan and Dr. J. Dutta	Recent study at Tocklai in an incubation experiment indicated that application of biochar, prepared at Tocklai from MP pruning tea litter, @ 4t/ha increased pH from 4.0 to 4.3 (data not published). and significantly yield of young tea	A biochar based quality organic manure for use in tea field will be developed.It is also requirement for tea industries.	**April-June-2019** Biochar was prepared from different biowaste viz., tea pruning litters (MP), ordinary woods, poultry manure in the glass house/vermicomposting unit at Soils department, TTRI adopting different procedures and biochar samples were tested for their nutrient contents.	Date of start (April-2019) Likely date of completion (Dec-2023)

and mature tea. **(New Proposal)**		(Phukan & Ramakrishnan, 2015). In an another study, a biochar based commercial organic manure (BIOSAT) was tested, funded by Anulekh Biotech, for its effect on yield of mature tea in a tea field at south bank. Data generated from the two years of experimentation indicated that annual application of Biosat @4 t/ha significantly produced highest yield of tea (19%) over RDF. Annual application of Biosat @ 2 t/ha with 100% RDF, 4 t/ha with 75% RDF and one time application of 8 t Biosat with 50% RDF could produce yield on par with 100% RDF. In the field trials, many researchers reported that biochar application improved soil quality, increased crop production and promoted plant growth (Major et al. 2010; Zhang et al. 2010). Liu *et al.* (2013) found benefits at field application rates typically below 10 tons/ha field application and reported that increases in crop productivity varied with crop type with greater increases for legume		<u>July-Aug-2019</u> Biochar based organic manure was prepared and tested for its effect on growth of young tea. Accordingly a pot culture experiment was initiated on the "'Effect of application of Biochar and Biochar based organic manure on soil properties, growth and yield biomass of young tea" during the period under review. <u>Oct-Dec-2019</u> Biochar was prepared from pruning litters and estimated for nutrient content. Ongoing pot culture experiment was monitored. Growth of tea plant under different treatments was recorded by measuring the collar diameter **March-June-2020 (Q1)** Pot culture experiment on 'Effect of application of Biochar and Biochar based organic manure on soil properties, growth and yield biomass of young tea" initiated during July-2019 was completely damaged (Most of the plants died) during Lock Down period. New set of pot culture experiment was initiated during April-2020 with the same treatments used in the previous experiment. At the time of planting (before the imposition of treatments) soil samples were collected from each pot and estimated for soil chemical, physical and microbiological for benchmark soil information. Initial growth of the young tea plants was recorded by measuring the collar diameter, number of leafs and plant height.	

		crops (30%), vegetables (29%), and grasses (14%) compared to cereal crops corn (8%), wheat (11%), and rice (7%).		The experiment is in progress and monitored carefully. During the period under review, biochar was prepared from pruning litters (LP/MP) and estimated for different parameters. pH, org. C, total N, total P_2O_5, total K_2O content in biochars varied from 10.6-11.8, 38.0-41.7%, 1.21-1.31%, 0.75-0.82% and 1.18-2.21% respectively. **July-September-2020 (Q2)** Growth of young tea in pot recorded after seven months of imposition of treatments indicated that combine application of biochar (BC) + biofertilizer (BF) + vermicompost (VC) at BC: VC: BF :: 0.1 : 1 : 0.1 and 0.2 : 1 : 0.1 significantly increased collar diameter over absolute control or BC, VC and BF when applied each separately. The dose of vermicompost applied was 600 kg/ha. The experiment is in progress. **Oct-Dec-2020 (Q3)** Soil samples were collected from the ongoing pot culture experiment on "Effect of biochar based organic manure on growth of young tea" to estimate the soil properties. **Jan-March-2021 (Q4)** Progress of the experiment was monitored **April-June-2021 (Q1)** Growth of plants was recorded during April-2021 i.e.,	

				after 12 months of imposition of treatments. Results indicated that combine application of biochar (BC) + biofertilizer (BF) + vermicompost (VC) in soil at certain combination significantly increased growth of young tea (measured by collar diameter) in pot over absolute control or BC, VC and BF when applied each separately. **July- September-2021 (Q2)** Progress of the experiment was monitored. Soil samples were collected from treated plots and analysis was under progress. **October- December-2021 (Q3)** The soil analysis result revealed that the soil pH maintained within the permissible limit for tea (4.81 to 5.45) and organic carbon percent varied from 0.85% to 1.16%. The available potassium content increased remarkably in biochar treated plots. After two year of experiment, indicated that the biochar treated plot exhibited healthy growth of plants. **Jan-March-2022 (Q4)** Soil samples collected from the pots during December, 2021were analyzed for different soil properties. Girths of the plants were also recorded. Progress of the experiment was monitored **April-June-2022 (Q2)** The treatments were imposed during month of April, 2022 and to evaluate the important physico-chemical characteristics of soil, the soil samples were collected before and after application of treatments.	

				The important soil parameters of collected samples are being analyzed.	
Climate and GIS					
3. Response of tea to elevated carbon dioxide and tempera-ture	Dr. K. Z. Ahmed	Atmospheric concentrations of carbon dioxide have been steadily rising, from approximately 315 ppm in 1959 to a current atmospheric average of approximately 385 ppm (Keeling et al., 2009). It is estimated that future doubling of atmospheric carbon dioxide concentration to about 700 ppm will risk an accompanying greenhouse rise of approximately 1.5 - 4.0°C in mean global surface temperature (Atwell et al., 1999). Current projections are for concentrations to continue to rise to as much as 500-1000 ppm by the year 2100 (IPCC, 2007). Research shows that elevated carbon dioxide increases photosynthetic rates, leaf area, biomass, and yield Allen, L. H. 1990).	Suitable cultivar for the future scenario will be screened out from this experiment	**July to September 2016 (Q3)** • An Open Top Chamber experiment with new set of clones were started in the year 2016. Clones were enriched with carbon dioxide at the level of 450ppm.After 250 hours of enrichment, chlorophyll estimations were done. Ranges of Chlorophyll a and Chlorophyll b are as follows **Temperature elevated:** Chlorophyll a: 1.614-3.944 mg/g Chlorophyll b: 0.613-1.571 mg/g **Temp+CO2 elevated:** Chlorophyll a: 1.280 - 3.772 mg/g Chlorophyll b: 0.466 - 1.558 mg/g **Ambient** Chlorophyll a: 1.49-4.56mg/g Chlorophyll b: 0.605-1.94mg/g After 250 hours of enrichment of plants with carbon dioxide at the level of 450ppm plant height, collar diameter, branch number, leaf number of plants were recorded. • Increase of plant height showed maximum range (7-110 cm) in elevated temperature and carbon dioxide condition followed by elevated temperature (4.5-101 cm) and ambient condition (0-54cm) • Increase of collar diameter showed maximum range (0.10-0.65 cm) in elevated temperature condition followed by elevated temperature and carbon dioxide (0.10-0.59 cm) and ambient condition (0.01-0.30cm).	Date of start (2014) Likely date of completion (2018) Extended up to 2022

				October-December 2016 (Q4) Physiological parameters (Photosynthesis, Stomatal conductance, Transpiration) were measured of the pot plants placed in the three environmental condition of the OTC experiment. Rate of photosynthesis was found to be in the following ranges • **Temperature elevated:** 6.5-18 µ mol m^{-2} S^{-1} • **Temp+ carbon dioxide elevated:** 8.1-33.7 µ mol m^{-2} S^{-1} • **Ambient:** 4-12.9 µ mol m^{-2} S^{-1} **January - March 2017 (Q1)** • The second phase of the experiment i.e. enrichment of plants with 500ppm carbon dioxide level has been started. **April-June 2017 (Q2)** • Plant height, collar diameter, branch number and leaf number of the pot plants placed in the three environmental condition of the Open Top Chamber experiment were measured after two hundred hours of enrichment of carbon dioxide at the level of 500ppm. The increase of plant height were found to be in the following ranges: **Temperature elevated**: 11-134.5 cm **Temp+ carbon dioxide elevated**: 15-144 cm **Ambient**: 2-61 cm The increase of collar diameter were found to be in the following ranges:	

				Temperature elevated : 0.16-1.06 cm **Temp+ carbon dioxide elevated**:0.19-0.94cm **Ambient**:0.03-0.52 cm • Leaf Length and width were measured after two hundred hours of enrichment of carbon dioxide at the level of 500ppm in the three environmental condition of the Open Top Chamber experiment ✓ Length of Leaf • **Temperature elevated**: 7.2-23 cm • **Temp+ carbon dioxide elevated**: 7-23.4 cm • **Ambient**: 6.1-16.8 cm ✓ Width of leaf • **Temperature elevated**: 3-9.8 cm • **Temp+ carbon dioxide elevated**: 2.3-9.4 cm • **Ambient**: 3-7.9 cm **July to September 2017 (Q3)** • Plant height, collar diameter, branch number and leaf number of the pot plants placed in the three • environmental condition of the Open Top Chamber experiment were measured after two hundred hours of enrichment of carbon dioxide at the level of 550ppm. The increase of plant height were found to be in the following ranges: **Temperature elevated**: 11-135 cm **Temp+ carbon dioxide elevated**: 18-144 cm **Ambient**: 2-61 cm The increase of collar diameter were found to be	

			To find out the critical/ threshold values of CO_2	in the following ranges: **Temperature elevated** : 0.17-1.1 cm **Temp+ carbon dioxide elevated**:0.27-0.98 cm **Ambient**:0.01-0.54 cm. **<u>Oct-Dec 2017 (Q4)</u>** **Completed.** **March-June,2020 (Q2)** • Open Top Chamber facility was repaired and calibration of the sensors (Carbon dioxide, temperature and humidity) are in progress. • For the experiment pot plants will be required. So the initial work for planting nursery plants in pots are in progress. **<u>July -Sept, 2020 (Q3)</u>** Initial works for planting nursery plants such as soil collection, sieving, pot filling has been done. **Oct-Dec-2020 (Q 4).** Weekly yield data recorded till Nov-2020, indicated that 75% RDF in combination with either soil application of silica as Agrosilica @100 kg/ha or foliar application of silica @400 ml/ha either as Silpot or Agrosilica produced yield of tea at par (1640-1730 KMTH) with 100% recommended doses of NPK (1710 KMTH). **<u>January - March 2021(Q1)</u>** • 1st batch of samples were collected, deactivated, dried, grinded and sent to Biochemistry department for quality assessment. • The range of total catechin was found to be 13.86-	

				16.22%, 14.46-16.48% and 10.06-12.6% under elevated temperature, elevated temperature + carbon dioxide and ambient environment respectively. **<u>April-June,2021 (Q2)</u>** Shoot samples from all the cultivars were collected, deactivated for quality parameter study during this period. **<u>July-September, 2021 (Q3)</u>** • To find out the critical/ threshold values of carbon dioxide, enrichment of plants in one of the chamber with 550ppm carbon dioxide has been started. After hundred hours of enrichment height of the pot plants placed in the three conditions of the OTC experiment were measured. Increase of plant height varies from 5-70.9 cm, 16.9-74.4 cm and 0.4-23.8 cm under elevated temperature, elevated temperature + carbon dioxide and ambient environment respectively. • After hundred hours of enrichment collar diameter of the pot plants placed in the three conditions of the OTC experiment were measured. Increase of collar diameter varied from 0.03-0.52 cm, 0.06-0.51 cm and 0.02-0.35 cm under elevated temperature, elevated temperature + carbon dioxide and ambient environment respectively. **<u>Oct-Dec-2021 (Q 4).</u>** • After hundred hours of enrichment, branch	

				numbers of the pot plants placed in the three conditions of the OTC experiment were counted. Increase of branch number varies from 1-19, 2-15 and 1-10 numbers under elevated temperature, elevated temperature + carbon dioxide and ambient environment respectively. • The enrichment has been elevated to 650 ppm currently and 100 hours of enrichment at 650 ppm will be completed during this period. **<u>January - March 2022(Q1)</u>** • 2nd batch of samples were analyzed for quality assessment. • The range of total catechin was found to be 11.20-15.18%, 12.63-15.87% and 12.59-17.57% under elevated temperature, elevated temperature+ carbon dioxide and ambient environment respectively. • Enrichment of plants with 650 ppm carbon dioxide level has been completed. After hundred hours of enrichment, plant height, collar diameter, branch number and leaf number of the pot plants placed in the three conditions of the OTC experiment were measured. • Increase of plant height varies from 6-108.9cm, 31.5-107 cm and 1-42.5cm under elevated temperature, elevated temperature+ carbon dioxide and ambient environment respectively. • Increase of collar diameter varies from 0.04-0.84cm, 0.07-0.79 cm and 0.03-0.39cm under elevated temperature, elevated temperature+ carbon dioxide and ambient environment respectively. • Increase in branch number varies from 0-24 nos, 1-19 nos and 2-12 nos under elevated temperature, elevated temperature+ carbon dioxide and ambient environment respectively. • Increase in leaf number varies from 13-81 nos, 9-102	

				nos and 2-36 nos under elevated temperature, elevated temperature+ carbon dioxide and ambient environment respectively. • The enrichment has been elevated to 750 ppm currently and 100 hours of enrichment at 750 ppm will be completed shortly. **April-June, 2022 (Q2)** • Enrichment of plants with 750 ppm carbon dioxide level has been completed. After hundred hours of enrichment, plant height, collar diameter and leaf number of the pot plants placed in the three conditions of the OTC experiment were measured. • Increase of plant height varies from 10-110.9 cm, 35-107cm and 1.3-42cm under elevated temperature, elevated temperature+ carbon dioxide and ambient environment respectively. • Increase of collar diameter varies from 0.03-1.46cm, 0.16-1.55 cm and 0.15-0.66 cm under elevated temperature, elevated temperature+ carbon dioxide and ambient environment respectively. • Increase in leaf number varies from 13-99 nos, 25-100 nos and 4-62 nos under elevated temperature, elevated temperature+ carbon dioxide and ambient environment respectively. • The enrichment has been elevated to 850 ppm currently and the work is in progress.	
4. To screen out suitable tea (*Camellia sinensis* (L).O.Kuntze)	Dr . K. Z. Ahmed		• To study the impact of elevated temperature and carbon dioxide on	• As advised by Dr.A.Kumar(Mentor,Climate)we approached a local firm for preparation of the system.The firm gave an estimate which was communicated to both our Chairman (SAC) and	**2020-2023**

cultivars for future climate change scenario in Free Air Carbon Enrichment (FACE) and Free Air Temperature Enrichment (FATE) **(New Proposal)**			growth parameters of tea in field condition. • To evaluate the physiological characters of the tea cultivars including major mineral nutrient uptake under future climate scenarios with special reference to elevated carbon dioxide and temperature. • To evaluate the effect of environmental factors on biochemical characters that confer tea quality. • Assess the impact of elevated carbon dioxide and temperature on	Dr. A. Kumar for their kind advice. • Based on the last SAC meeting held on 4th June 2021, wherein it was suggested to conduct a virtual meeting with different vendors so that the price can be negotiated. The firms who can fabricate the same are looked for. • Virtual meeting was conducted and minutes prepared and submitted	

			different soil parameters including major mineral nutrient content		
5. Climate trend Analysis in Assam with respect to tea production (2014-Till now)	Dr. R. D. Baruah	• Data on climatic parameters from seven meteorological stations of TRA are regularly updated and analysed.		**<u>July-September, 2021 (Q3)</u>** To find out the changes of rainfall, rainy days, maximum temperature, minimum temperature, evaporation, relative humidity, and sunshine hour over the past fifty years in the Cachar region of Assam, database was developed with data from 1970 to 2019 for decadal analyses. During the period the following analyses were done • Decadal analysis of fifty years rainfall and rainy days data were done. Yearly total rainfall were found to be in the range from 1857.4 to 4097.2 mm. Statistical analysis of decadal data of total rainfall showed significant variation (P=0.001). Compared to the first two decades, (1970-79, 1980-89), the last three decades showed reduction in total rainfall. Fifty years of rainy days (1970-2019) data recorded at Silcoorie Met Station, TRA showed the range from 119 to 183 days. Statistical analysis of decadal data of total rainfall showed significant variation (P=0.01). Compared to the first two decades, (1970-79, 1980-89), the last three decades showed decrease in number of rainy days with maximum decrease in the last decade (2010-2019). • Decadal analysis of fifty years maximum and minimum temperature data were done. Maximum temperature data were found to be in the range from 29.3 to 32.0 ^{0}C. Decadal analysis of fifty years data of maximum temperature showed	

				significant (P=0.001) variation. Results of decadal analysis showed a gradual increase in maximum temperature with slight decrease in fourth decade followed by maximum increase in the last decade. Fifty years of average minimum temperature data (1970-2019) showed the range from 13.8 to 20.9 ^{0}C. Statistical analysis of decadal data of minimum temperature showed significant (P=0.001) variation. Minimum temperature were found to be more in the last two decades compared to first second and third decade. • Decadal analysis of fifty years of Relative Humidity both morning and afternoon data were done and the results were found to be in the range 90 to 97 % in the morning hours. Statistical analysis of decadal data of relative humidity showed significant (P=0.001) variation. Relative Humidity (Morning) seemed to slightly increase in the second decade (1980-1989) but after that followed a decreasing trend. On the other hand analysis of fifty years of Relative Humidity (Afternoon) data (1970-2019) recorded at Silcoorie Met Station, TRA showed the range 56 to 80% during the afternoon hours. Statistical analysis of decadal data of relative humidity (Afternoon) showed significant (P=0.001) variation. Relative Humidity followed a increasing trend except the fourth decade (2000-2009) where it has shown substantial decrease. **<u>Oct-Dec-2021 (Q 4)</u>** • Decadal analysis of fifty years of sunshine hours data (1966-2015) recorded at Silcoorie Met Station, TRA showed the range from 4.9 to 7.2 hours. Statistical analysis of decadal data of sunshine hours showed	

				significant variation (P=0.001). Compared to the first and second decade (1966-1975, 1976-1985), all the following decades showed reduction in sunshine hours. Monthly variation was also found to be significant (P=0.001). On the other hand analysis of fifty years of evaporation (1966-2015) recorded at Silcoorie Met Station, TRA showed the range from 741.2 to 1305.8 mm. Statistical analysis of decadal data of evaporation showed significant variation (P=0.001). Compared to the first decade (1966-1975), all the following decades showed decrease in amount of evaporation. Monthly variation was found to be significant (P=0.001). • Decadal analysis of forty years of total rainfall data (1981-2020) recorded at Thakurbari Met Station, North bank, TRA showed the yearly rainfall range from 1528.3 to 3111.6 mm. Compared to the first three decades, the last decade (2011-2020) showed reduction in total rainfall, though statistically not significant. Reduction in the amount of rainfall in the last decade compared with the average rainfall of first three decades was found to be 193.2 mm. Forty years of rainy days (1981-2020) data recorded at Thakurbari Met Station, North bank, TRA showed the range from 108 to 165 days. Statistical analysis of decadal data of rainy days showed significant variation (P=0.001). Compared to the first three decades, the last decade showed significant decrease in total number of rainy days. • Decadal analysis of forty years maximum and minimum temperature data is being carried out. **<u>January - March 2022(Q1)</u>** • Decadal analysis of forty years (1981-2020) of Relative Humidity data during the morning hours recorded at Thakurbari Met Station, North Bank, TRA showed the range from 88 to 96%. Statistical	

				analysis of decadal data showed significant (P=0.001) variation. Relative Humidity (morning) showed a decreasing trend in the third and the fourth decades. Decadal analysis of forty years (1981-2020) of Relative Humidity data during the afternoon hours showed the range from 57 to 67%. Statistical analysis of decadal data showed significant (P=0.001) variation. Compared to the first two decades the last two decades followed a decreasing trend. • Decadal analysis of forty years sunshine hours data (1979-2018) recorded at Thakurbari Met Station, TRA showed the range from 4.8 to 6.8 hours. Statistical analysis of decadal data of sunshine hours showed significant variation (P=0.001). Compared to the first decade (1979-88), all the following decades showed reduction in sunshine hours. Forty years of evaporation (1979-2018) data showed the range from 654 to 1155 mm. Statistical analysis of decadal data of evaporation showed significant variation (P=0.001). Compared to the first (1979-88) decade, all the following decades showed decrease in amount of evaporation. • Decadal analysis of maximum and minimum temperature data recorded at Taipoo Met Station, Terai, TRA is being carried out. **April-June, 2022 (Q2)** • Decadal analysis of forty years of average maximum temperature data (1981-2020) recorded at Terai Met Station, TRA showed the range from 28.3 to 31.6^{0}C. Statistical analysis of decadal data of maximum temperature showed significant	

				(P=0.001) variation. Compared to the first decade, the second decade showed an increase in maximum temperature and subsequently followed a decreasing trend. Forty years of average minimum temperature data (1981-2020) recorded at Terai Met Station, TRA showed the range from 17.1 to 20.5^{0}C. Statistical analysis of decadal data of minimum temperature showed significant (P=0.001) variation. Minimum temperature was found to exhibit alternating trends in each decade with maximum increase in minimum temperature in the last decade. • Analysis of forty years of Relative Humidity data (1981-2020) during the morning hours recorded at Terai Met Station, TRA showed the range 85 to 97 %. Statistical analysis of decadal data of relative humidity showed significant (P=0.001) variation. Relative Humidity seemed to follow an increasing trend till the third (2000-2010) and then decreased in the fourth decades (2011-2020). Forty years of Relative Humidity data (1981-2020) during the afternoon hours showed a range from 53 to 70%. Statistical analysis of decadal data of relative humidity showed significant (P=0.001) variation. Relative Humidity seemed to follow an increasing trend till the third (2000-2010) and then decreased in the fourth decades (2011-2020). Forty years of average rainfall data (1981-2020) recorded at Terai Met Station, TRA showed the range from 2126 mm to 4537 mm. Statistical analysis of decadal data of rainfall showed non significant variation. However, compared to first decade rest of the decades showed reduction of total rainfall. Forty years of average rainy days data (1981-2020) recorded at Terai Met Station, TRA showed the range from 72 to 145 days.	

				Statistical analysis of decadal data of rainy days showed significant (P=0.01) variation. Number of rainy days followed a decreasing trend in each decade.	
Agronomy					
6. Alternative method of weed control **(New Proposal)**	Dr. S.P Baruah		• To study the effect of cover crop on weed control in tea. • To study the effect biocontrol agents on weed control in tea. To develop a package of practice on biological methods of weed control in tea.	**March 2020-June 2020 (Q2)** Trial plot laying out completed. Treatment application is going to start shortly. Alternate method of weed control in tea: Treatments – T 1 –Black plastic mulch 10 cm away from the collar region of young tea . T 2 –PP non woven synthetic mulch in strip around the collar region of young tea. T 3 – Guatemela mulch T 4 – Rice Straw mulch T 5 —Cowpea as cover crop T 6 – Green gram as cover crop T 7 – Black gram as cover crop T 8 – Pre emergent herbicide at recommended dose T 9 – Manual weeding. **July 2020 – September 2020 (Q3)** Treatment application completed and data collection is going on (crop yield, soil temperature, biometric observations, microbial count in soil.) **October-December, 2020 (Q4)** Yield data for the year 2020 and other observations recorded. Statistical analysis is being done.	2020-2023

				January- March, 2021 (Q1) In treatment 5,6,7 (T5- cowpea as cover crop, T6- green gram as cover crop, T7- black gram as cover crop) the weed growth was maximum due to inability of the selected crops to cover the ground. The treatments need to be recasted. Advice solicited. Soils samples were sent for microbial count. Result awaited. Biometric count was not taken and planned for the next year. The other parameters like soil temperature and weed growth are submitted in the attached sheet for perusal and advice. **April- June, 2021 (Q2)** In the experiment on alternate method of weed control fresh organic mulch materials added. Weekly crop yield is being recorded. **July- September, 2021 (Q3)** Weekly crop yield recorded along with fineness count. Plant protection measures were taken. **October- December (Q4)** Weekly crop yield recorded along with fineness count. Infilling was done in the month of October. **January-March, 2022** In the experiment on 'alternate method of weed control', crop data of 2021showed mark increase in yield in the treatment was observed where water hyacinth was used as mulch material (T3). However, the treatment was not found to be significant. **April-June, 2022 (Q2)** In the experiment on 'alternate method of weed control', mulching materials redeployed in the plots	

				as per treatments. Cover crop seeds sowing completed. Weekly crop yield along with fineness count recorded.	
7. Application of microbial fertigation through drip irrigation **(New Proposal)**	Ms. A. Dutta Bora		• To study the effect of soil additives on soil health, growth and yield of tea. • To study the effect of soil additives on quality and nutrient uptake of tea. • To study the efficacy of soil additives in combination with inorganic fertilizer • To find out a suitable irrigation scheduling to meet the water requirement of tea. •	**March 2020-June 2020** Non fungal microbials chosen for treatment combinations and with the collaborative support of the Mycology and Microbiology department the project started. **Experiment Name**: Effect of microbial bio fertilizer on soil health, growth and yield of tea under drip irrigation. **Details:** T-1: I_1F_1 (Irrigation at 100% ETloss+100%RDF+2% microbial consortium) T-2: I_1F_2 (Irrigation at 100%ET loss+75%RDF+2% microbial consortium) T-3: I_1F_3 (Irrigation at 100%ET loss+50%RDF+2% microbial consortium) T-4: I_2F_1 (Irrigation at 75% ET loss+100%RDF+2% microbial consortium) T-5: I_2F_2 (Irrigation at 75% ET loss+75%RDF+2% microbial consortium) T-6 : I_2F_3 (Irrigation at 75% ET loss+50% RDF+2% microbial consortium) T-7 : I_3F_1 (Irrigation at 50% ET loss+ 100% RDF+ 2% microbial consortium) T-8 : I_3F_2 (Irrigation at 50% ET loss+75% RDF + 2% microbial consortium) T-9 : I_3F_3 (Irrigation at 50% ET loss+ 50% RDF +2% microbial consortium) T-10: Rainfed control + Boardcasting of RDF T-11: Sole application of 2% microbial consortium through drip (2% consortium of *Azotobacter* + *Azospirillum* +	

				Bacillus subtilis) Abbreviation : ET loss: Evapotranspiration loss, RDF: Recommended Doses of Fertilizer • Experiment is layout in the existing drip irrigation plots with integration of 2% microbial consortium (Azotobacter+Azospirillum+BST) with irrigation and fertigation. • 1st split of Fertigation have been applied till the month of June. • Control measures for pest and disease taken **July-September, 2020** • 2% microbial consortium through drip have been applied with second split of fertigation. • Weekly crop data recording is going on. **October-December, 2020** • Collection of soil samples for microbial count after treatment application is completed. crop yield data recorded and analysis of data is in progress. **January- March,2021** • In drip irrigation experiment, modification of treatment has been done with integration of 2 percent microbial consortium (Azotobacter + Azospirillum + PSB) to see the effect on soil health and yield in tea • In 2020, the bushes are unpruned and due to covid 19 pandemic situation, only 2 application of microbial treatment can be applied along with	

				second split of fertigation. Moreover, no positive effect on yield can be seen under treatment with sole application of microbial consortium in 1st year of experimentation. But in case of treatment with Irrigation at 100% ETloss+100%RDF+2% microbial consortium there is 18.66 percent increase in yield over rainfed control. • Soil samples were sent for microbial count after 10, 20 and 30 days of treatment application. **April- June, 2021** Treatment application of inorganic fertilizer as well as biofertilizer are given in the field. Soil samples were collecte for microbial analysis and sent to Mycology & Microbiology department. Weekly crop yield is being recorded. **July- September, 2021 (Q3)** Treatment application of inorganic fertilizer as well as biofertilizer were applied in the field for the month of July, August and September. Soil samples were collected for microbial analysis in all these three months. Weekly crop yield recorded along with fineness. **October- December (Q4)** Treatment application of inorganic fertilizer as well as biofertilizer were applied in the field for the month of October and November. Soil samples were collected for microbial analysis. Weekly crop yield recorded along with fineness. **January- March, 2022 (Q1)** Irrigation started in 'Effect of microbial bio fertilizer	

				on soil health, growth and yield of tea under drip irrigation'. Soil samples collected for microbial analysis. Crop data sent for statistical analysis. Report is being prepared. 1st split of manuring as per schedule is initiated from the month of February. **April- June, 2022 (Q2)** Treatment application of inorganic fertilizer as well as biofertilizer were applied in the field during the period. Soil samples were collected for microbial analysis. Weekly crop yield recorded along with fineness.	
8. Effect of DDS on yield, crop distribution and quality of tea **(New Proposal)**	Dr. S.P. Baruah		• Standardisation of DDS practiced in commercial gardens. • To observe recommendability of DDS.	**April- June, 2022 (Q2)** A new experiment as advised by Dr. A.C. Barbora, Proj. Adviser started this year with the following treatments. Treatments- **T1: DDS at 3 cm below prev. DS height & Tip over 3 leaves** **T2: DDS at 3 cm below prev. DS height & Tip over 2 leaves** **T3: DDS at 3 cm below prev. DS height & Tip over 1leaf** **T4: DDS at previous DS height & Tip over 3 leaves** **T5: DDS at previous DS height & Tip over 2 leaves** **T6: DDS at previous DS height & Tip over 1 leaf** **T7: DDS at 3 cm above prev. DS height & Tip over 3 leaves** **T8: DDS at 3 cm above prev. DS height & Tip over 2 leaves** **T9: DDS at 3 cm above prev. DS height & Tip**	2022-2024

				over 1 leaf **T10: LP & Tipping as per recommended practice (Control)** Treatment applications were done. Weekly crop yield recorded with fineness count. Made tea samples were prepared for quality evaluation.	
Plant Physiology and Breeding					
9. Development of climate resilient quality and high yielding planting material.	Dr. S. K. Singh/ Dr. P. K. Patel/ Dr. B. Gogoi	The organized effort on breeding for tea improvement was made after the department of Botany was established in 1930. Since tea is grown in a wide range of agro-climatic condition, the breeding programme needs to be undertaken considering the specific requirement of the region (Bezbaruah, 1968). The planned breeding, however, delayed till 1946 due to various reasons. The present tea improvement effort of North-East India is based on clonal selection which was further extended to biclonal seed varieties (Singh, 1982).	Promising clones and seed stocks will be identified	**July -September 2016 (Q3)** • Mortality percentage and growth performance of elite clone and seed stocks were recorded from the newly established LTT at Borbheta experimental plot. Selection like NBS-1, and entries like NJ6/24, S.3A/3, St. 667, TTRI 1, TV1 and Narshingpore 18 are performing well at initial stage. • Yield performances of 527 series clones under long term trial were compared with the yield of controls (TV1 and TV20). • Among the selected clones under Borbheta progeny selections trial (Long term trial), clone 650/8 produced higher yield over control (TV 1). • Clones like Sikkim-1, BJ-2, Kopati 1/1, Bennoubhru -157, Bennoubhru-777, Bennoubhru-688, Balasum 9/3/76, Phobsering 1404 and Takdah 246 collected from CPS Ging, Darjeeling were planted at Borbhetta Tea Estate. • Plant physiological parameters viz., photosynthesis, transpiration rate and water use efficiency (WUE), were recorded in five promising clones under long term trial along with three controls (TV1, S.3A/3, TA 17/1/54). High	Date of start 2016 Likely date of completion: 2023

				rate of photosynthesis and WUE is recorded in clone 652 followed by Clone 662. **October – December, 2016 (Q4)** • Yield performances of 527 series clones under long term trial were compared with the yield of controls (TV1 and TV20). • Among the selected clones under Borbheta progeny selections trial (Long term trial), clone 650/5 produced higher yield over controls (TV 1 and TV30). • Yield performances of 11 Deepling clones under long term trial were compared with the yield of control. Clone DL 28 produced highest yield over the controls. • Plant physiological parameters viz., photosynthesis, transpiration rate and water use efficiency (WUE), were recorded in five promising clones under long term trial along with three controls (TV1, S.3A/3, TA 17/1/54). High rate of photosynthesis and WUE is recorded in clone Clone 662. • Effect of mechanized harvesting on physiological attributes of Tea was studied during the month of October and November, 2016. **January-March, 2017 (Q1)** • Under long term trial clone 662 and 652 were found promising in terms of yield and quality as compared with TV1 and S.3A/3. Cuttings of clone 662 were supplied to TRA Dikom, North Bank and	

				NBRR&DC, Nagrakata and cuttings of clone 652 were supplied to TRA NBRR&DC, Nagrakata, TRA North Bank and Meghalaya for propagation by the concerned centers. • Out of 10 tissue culture derived clones, clone 527/4 was found superior in terms of yield and quality as compared with controls (TV1 and TV20). Net photosynthesis rate and water use efficiency of this clone was either higher or at par with controls. 15 bush of the clone 527/4 which are not under long term trial were pruned for distribution of cutting in coming spring and autumn to different TRA centers. • Among the biclonal seed stocks under long term trial, ST. 673 (BJ-19 x S.3A/3) and ST. 643 (TV20 x BJ-19) found to promising in respect to yield and quality of CTC tea as compared to TS 520 (control). Net photosynthesis and water use efficiency was recorded highest in seed stock 673 followed by stock 643 as compared to control during the winter moisture stress period of December, 2016 and January, 2017. To assess the degree of drought tolerance ability 13 selected TRA reserved germplasm were evaluated and the data revealed that TG 40 had highest rate of photosynthesis and water use efficiency over the controls (TV 1, TV 20 and TV 25). **April to June, 2017 (Q2)** • Quality evaluation of 1st flush Darjeeling orthodox tea of St 560 (AV 2 x P312) has been completed. Based on data recorded during	

				different flushes St 560 found to be superior as compared with TS569 in terms of quality. • Clone 662 followed by clone 652 exhibited higher crop yields as compared to the yield of controls under long term trial. Higher rate of photosynthesis is also observed in those clones as compared to controls. • Among 10 somaclonal variants, clone 527/4 exhibited high green leaf yield with respect to control TV1. • Yield performances of seed stocks under long term trial were assessed. Stock 643 followed by ST 673 showed highest yield potential as compared to the yield of the control stock (TS 520). • To study the growth performance of three promising clones (clone 652, clone 662 & clone 527/4) under different agro-climatic condition, cuttings were supplied in different commercial tea gardens under Upper Assam and North Bank Advisory center. **July – September, 2017 (Q3)** • Higher yield potential was recorded in clone 662 compared to controls (TV1 and S.3A/3) and other clones under long term trial. High net photosynthesis was observed in clone 652 followed by clone 662. High water use efficiency (WUE) was recorded in clone 662.	

				• Among the tissue culture derived clones, clone 527/4 exhibited high green leaf yield with respect to the controls TV1 and TV20. • For assessment of promising seed stocks, Stock 668 followed by Stock 666 showed high rate of photosynthesis and water use efficiency (WUE) under long term trial. • To study the growth performance of three promising clones (clone 652, clone 662 & clone 527/4) cuttings were supplied to 10 commercial tea gardens and clones were propagated in nurseries. **October – December 2017 (Q4):** • Yield potential of promising seed stocks under long term trial was assessed. High green leaf yield was recorded in ST643 as compared to control, TS 520. • Among 7 entries under long term trial seed stock 726 exhibited highest green leaf yield and stock 721 exhibited lowest green leaf yield. • Plant physiological parameters were recorded in promising clones along with controls under long term trial. High rate of photosynthesis, water use efficiency (WUE) and leaf water potential (LWP) was observed in Clone 652 followed by clone 662. **January- March, 2018 (Q1)** • Two new clones under TV series, namely TV 34	

				and TV 35 are ready for provisional release. • Plant physiological parameters were recorded in clones under pipeline along with the controls (TV1, S3A3 and TA 17). High rate of photosynthesis (16.37µmol/m^2/s) and water use efficiency (5.48µmol/m.mol) were observed in clone 662. • Leaf water potential (LWP) of promising clones were assessed along with two controls (TV1 and S.3A/3). Lowest LWP was recorded in Clone 662 (9.50 –bar) followed by clone 652(10.00 –bar). Lower value indicates higher degree of drought tolerance. • Yield potential of biclonal seed hybrids under long term trial was assessed. High green leaf yield was recorded in ST643 as compared to control, TS 520. The second pruning cycle of the trial will be completed in 2018. **April to June, 2018 (Q2)** • Yield potential of biclonal seed stocks under long term trial was assessed. Stock 673 exhibited highest green leaf yield with respect to control, TS 520. • Plant physiological parameters were recorded in promising seed stocks under long term trial. High rate of photosynthesis (21.86µmol/m^2/s) and water use efficiency (2.65µmol/mmol) was recorded in ST 643 compared to control, TS 520. • Yield potential of germplasm 650 was assessed along with controls (TV 1 and TV 30) in Borbheta progeny selection trial. Higher yield recorded in germplasm 650/5 with respect to control, TV1. • New long term trial established with the progenies	

				of improved seed *jats* collected from the in-situ seed baries at Borbheta experimental tea estate. **July to September, 2018 (Q3)** • Yield potential of seed stocks under long term trial was assessed. Stock 667 showed higher yields compared to control (TS 520). • Plant physiological parameters were assessed in promising seed stocks under long term trial. Higher rate of photosynthesis observed in ST 643 (20.06 µmol/m^2/s). Low rate of transpiration (8.86 mmol/m^2/s) and high water use efficiency (WUE) observed in ST 673 (2.27 µmol/mmol) compared to control (TS 520). • Yield potential of germplasm 650 (Borbheta progeny selection trial) was assessed. Higher yield recorded in germplasm 650/5 with respect to controls, TV1 and TV30. • Yield potential of germplasm (ST 721, ST 722, ST 723, ST 724, ST 725, ST 726) under long term trial at New Botanical Area were assessed along with control (TS 506). Higher yield recorded in ST 725, compared to control (TS 506) and others. **October – December 2018 (Q4):** • Yield potential of seed stocks under long term trial was assessed. St. 673 showed higher green leaf yield followed by St. 643 compared to control stock, TS 520. • Physiological parameters of promising seed stocks under long term trial were assessed.	

				Higher rate of photosynthesis and water use efficiency was recorded in St. 643 compared to control (TS 520). • Yield and physiological data was recorded in long term trial at Dikom tea estate. • In Situ selected population were planted in long term trials at Deha and Nahartoli Tea Estate. **January-March 2019 (Q1):** • Two new clones were released under TV series as TV 34 (clone 662) and TV 35 (clone 652) in February, 2019. These two clones were found promising in terms of yield and quality as compared with TV1 and S.3A/3. • Under long term trial for assessment of promising seed stocks. Higher rate of photosynthesis and water use efficiency was recorded in St. 673 compared to control (TS 520) and others. • Leaf water potential (LWP) and leaf wax content of promising seed stocks was assessed along with control (TS 520). Highest LWP and leaf wax content was recorded in St. 673. • Under *In* situ seed production trial, seeds were collected from the 11 different clonal combinations separately and 695 seeds were sown into the nursery bed for germination. **April to June 2019 (Q2)**	

				• Cutting supplied of the newly released clones i.e. TV 34 and TV35 to the eight members T.E. of Assam for multiplication namely as Socklantinga T.E., Joboka T.E., Tata Amalgameted; Chandighat T.E., Moheema T.E. etc. • Under long term trial for assessment of promising seed stocks. Higher rate of photosynthesis and water use efficiency was recorded in St. 673 compared to control (TS 520) and others. Besides, photochemical efficiency of the PSII (fv/fm) or maximum quantum yield of promising seed stocks was also assessed. Maximum quantum yield (0.71) was significantly higher in St. 673 followed by St.643 (0.68) compare to the control TS 520 (0.41). • Under *In* situ seed production trial, seeds were germinated well of the 11 different clonal combinations, obtaining plantable height, all seed planting materials will be transfer in the field along with control. **July to September 2019 (Q3)** • Cutting supplied of the newly released clones i.e. TV 34 and TV35 nodal cuttings have sent to the two members T.E. of Assam (Pengaree T. E., Kanu. T. E) and Nagrakata sub- station, West Bengal for evaluation. **October to December 2019 (Q4)** • Multiplications of newly released clone TV34 have been initiated. Total 30 numbers of seedling tea plants were grafted with TV 34 cuttings to	

				fulfill the demand of cutting. • Under long term trial for assessment of promising seed stocks. Physiological and yield performance of seed stocks under long term trial were assessed. Higher yield was recorded in St. 673 followed by St. 643 over control TS 520 which also showed net photosynthesis (24.2µmolm-2s-1) and water use efficiency (4.05 µmol mmol-1). • Among the tissue culture derived clones, clone 527/4 exhibited high green leaf yield with respect to the controls TV1 and TV20. • Collected the tea seeds from the previous year hand crossing combination for germination. Total 112 seeds were collected and transferred into germination pit for better germination. **January to June, 2020 (Q1 + Q2)** • Till date, total 52 tea plants were grafted with TV34 scion. The growth of grafted plant is satisfactory. • Department had supplied nodal cuttings of newly released clones (TV 34 and TV 35) to the member tea estates and regional center during lockdown period. The benefited gardens are Shakomoto tea estate, Dhekiojuli tea estate, Bhagatpur tea estate and Kharikatia tea estates. • Supply of popular clone, department had supplied cuttings to the Teok tea estate. • Some cuttings of purple tea had sent to Dissoi t.e and NBRRDC, TRA, Nagrakata for evaluation purpose. • Under long term trial for assessment of promising	

				seed stocks. Higher rate of photosynthesis and water use efficiency was recorded in St. 673 compared to control (TS 520) and others. Data collection is in progress. • Total 15 nursery beds have been marked in the Borbhetta, Tocklai nursery for the multiplication of promising planting materials as TV34, TV35, TTRI1, TTRI2, BJ19, TV20 and S3A/3. • Among the tissue culture derived clones, clone 527/4 exhibited high green leaf yield with respect to the controls TV1 and TV20. • Crop yield data of germplasm 650 (Borbhetta progeny selection) were assessed along with the controls (TV1 and TV30) during 2019. Among these germplasm 650/12 followed by 650/1 produced higher yield. Further evaluation is in progress. **Screening of genotypes for drought tolerance** • Tweleve (12) selected TRA reserved germplasms in the nursery were evaluated under rainout shelter along with controls (TV21 and TV25). Net photosynthesis (pn), water use efficiency (WUE), carboxylation efficiency (ci/ca), photochemical efficiency (fv/fm) or chorophyll fluoresence were significantly higher in TG 44 (25.03, 10.23 and 0.797) followed by TG 37 (19.38, 9.50 and 0.769) compare to the controls TV1 (12.67, 4.62 and 0.562) and TV25 (14.13, 5.31 and 0.696) respectively. Whereas, maximum root: shoot ratios were observed in TG 37 (1.12) followed by TG 44 (1.01) compare to the control. Evaluation is in progress.	

				July-September, 2020 (Q3) In the year of 2020, clonal selection work initiated in Dufflating tea estate. Four old seed grown section have been found suitable for clonal selection work. Twelve (12) selected TRA reserved germplasm in the nursery were evaluated under rainout shelter along with controls (TV21 and TV25). Maximum photochemical efficiency (fv/fm) or chlorophyll fluorescence was recorded in TG37 (0.773) followed by 305/11 (0.702) compare to the controls TV21 (0.552) and TV25 (0.616). Further evaluation is in progress. From the different Long term trial of department, 40 orthodox tea samples have been prepared and sent for organoleptic evaluation. Department has planted 50 tea plants at Tocklai to raise as micro seed baries. The clones are as follows: S3A3, TV19, TV20, AV2, TV31, TV13 and BJ19. Crop yield data of germplasm 650 (Borbhetta progeny selection) were assessed along with the controls (TV1 and TV30) during 2019. Among these germplasm 650/12 followed by 650/1 produced higher yield. Further evaluation is in progress. **October-December, 2020 (Q4)** • Yield potential of seed stocks under long term trial was assessed. Higher yield recorded in St. 643 compared to control TS 520. Made tea samples of the same had sent for organoleptic evaluation. • Physiological performance of seed stocks under	

				long term trial was assessed. Net photosynthesis (pn) and, water use efficiency (WUE) recorded was higher in St. 643 (22.5µmolm^{-2}s^{-1}, 9.31µmolm.mol^{-1}) followed by St. 673 (21.8 µmolm^{-2}s^{-1}, 8.91µmolm.mol^{-1}) over control TS 520 (14.87 µmolm^{-2}s^{-1}, 4.71 µmolm.mol^{-1}). Maximum photochemical efficiency (fv/fm) was recorded in St.673 (0.63) followed by St.643 (0.52) over control TS 520 (0.44). • Initiated clonal selection program in Dufflating T. E. Total 116 bushes were selected from the four old seed grown section of tea estates. All the selected bushes were pruned for taking cuttings in the April-May, 2021. A detail map of the old section (14, 16, 17 and 18) has been prepared a provided to the garden for future reference. • Total 70 plants were planted at Tocklai nursery for crossing program. The clones are as follows: S.3/A3, TV19, TV20, AV2, TV13 and BJ19. • Twelve (12) selected TRA reserved germplasm were evaluated under rainout shelter condition along with controls TV21 and TV25 for assessment of drought tolerance. Photochemical efficiency (fv/fm) or chlorophyll fluorescence were higher in TG 37 (0.627) followed by TG 34 (0.621) compared to the controls TV1 (0.517) and TV25 (0.564) respectively. **January- March, 2021 (Q1)** • Initiated clonal selection program in Dufflating T. E. Total 116 bushes were selected from the four old seed grown section of tea estates. All the selected bushes were pruned and growth of the scion is good. In the month of May –June, 2021, plan has set up for collection of cuttings and propagate in the nursery.	

				• Yield potential of seed stocks under long term trial was assessed. Higher yield was recorded in St. 643 compared to control TS 520. Organoleptic data have been compiled. Overall valuations of St. 643 have been better as compared to TS 520. • Leaf water potential (LWP) and leaf wax content of promising seed stocks was assessed along with control (TS 520). Highest LWP and leaf wax content was recorded in St. 673. • Multiplication of newly released clone TV34 has been initiated. 10 numbers of seedling tea plants were grafted with TV 34 cuttings to fulfill the demand of cutting in future. • Yield performances of 527 series clones under the long term trial were compared with the yield of controls (TV1 and TV20). The highest yield recorded in Clone 527/4 over the control in the year 2020. • Crop yield of five (5) triploid clones along with TV1 as control were assessed during 2020. Among the clones high crop yield was recorded in clone 615/11. • Crop yield data of germplasm 650 (Borbhetta progeny selection) were assessed along with the controls (TV1 and TV30) during 2020. Among these germplasm 650/12 followed by 650/1 produced higher yield. • To develop drought tolerant and early flusher varieties, screening of genotype are in progress. • Biochemical analysis and Taster's score have	

				recorded for polyploidy clones. Polyploidy clone, 615/11 is performing better in respect to other clones. Further evaluation is in progress. • Demonstrate the cleft grafting technique at member tea estates. A special visit was made to Rangajan tea estate to demonstrate the grafting technique in the tea bushes. Total 60 suitable branches of the root stocks were grafted with scion for rapid multiplication. • Certified the two Seed Barie of Kailashpur tea estates. • Supplied 08 units of Tocklai Betjan seeds to the Morghum & Gulma tea estate, W.B. **April-June, 2021 (Q1)** • Yield potential of seed stocks under long term trial was assessed. Higher yield recorded in St. 673 compared to control TS 520. • Photochemical efficiency of PSII was recorded in promising seed stocks under long term trial. Maximum photochemical efficiency or chlorophyll fluorescence was recorded in St.673 (0.564) followed by St.668 (0.443) compare to the controls TS 520 (0.412). • Yield performances of 527 series clones under the long term trial were compared with the yield of controls (TV1 and TV20). The highest yield recorded in Clone 527/4 over the control. • Crop yield data of germplasm 650 (Borbhetta progeny selection) were assessed along with the controls (TV1 and TV30). Among these germplasm 650/12 followed by 650/1 produced	

				higher yield. • Photochemical efficiency of PSII was recorded in a long term trial (field screening of water logging tolerant clones). Maximum photochemical efficiency was recorded in TRA/D/SNT10/P3 (0.565) followed by TV23 (0.560). **July-September, 2021 (Q3)** • Yield potential of seed stocks under long term trial was assessed. Higher yield recorded in St. 673 compared to control TS 520. • Photochemical efficiency of PSII was recorded in promising seed stocks under long term trial. Photochemical efficiency or chlorophyll fluorescence was significantly higher in St.673 (0.678) followed by St.668 (0.592) compare to the control TS 520 (0.492). • Yield performances of 527 series clones under the long term trial were compared with the yield of controls (TV1 and TV20). The highest yield recorded in Clone 527/4 over the control. • Crop yield data of germplasm 650 (Borbhetta progeny selection) were assessed along with the controls (TV1 and TV30). Among these germplasm 650/12 followed by 650/1 produced higher yield. • Supplied clonal cuttings to the member tea estates (Jaboka & Ratanpur).	

				• Department had renewed seed *barie* certificates for Koomtai Tea Estate (TS 463, TS 589), Kailashpur Tea Estate (TS 520, TS 506) and Brahmaputra Valley Tea Seed Industries (TS 520). • New trial was laid out with the progeny plants derived from six micro seed *baries* at New Botanical area along with control stocks TS 463 and TS 520. **October-December, 2021 (Q4):** • Yield potential of seed stocks under long term trial was assessed. Higher yield recorded in St. 673 compared to control TS 520. • Photochemical efficiency of PSII was recorded in promising seed stocks under long term trial. Photochemical efficiency was significantly higher in St.673 (0.730) followed by St.643 (0.552) compare to the control TS 520 (0.457). • Under clonal selection programme, selected planting materials from the old seed grown section of Dufflating tea estate (section no. 14, 16, 17 and 18) were planted in nursery for evaluation. • Under the *In situ* conservation programme, tea seeds were collected from Deha tea state. Work is under progress. • Department has renewed seed barie certificates for Socklatinga T.E. (TS 491, TS 520 and Thurbo T.E. (TS 569).	

				January-March, 2022 (Q1): • Photochemical efficiency of PSII, leaf wax content and electrolyte leakage was estimated in selected reserved germplasm for screening moisture stress tolerance. Maximum photochemical efficiency recorded in 19/33/41. • For screening of germplasm, supplied 28 diverse seed materials to Socklatinga and Bokahola T.E. to know the nursery performance and establishment of a new Long term trial. • A special visit was made to Sunderpur tea estate along with advisory department to rectify the problem associated with seed yield. • Visited North Bank, Advisory Centre, TRA, for establishment of trial on growth regulator and DUS characterization of TV 13, TV 17 and TV 31 was done. Few garden series clones were marked for multiplication and DUS characterization. **April-June, 2022 (Q2):** • Yield potential of seed stocks under long term trial was assessed. Higher yield recorded in St. 643 compared to control TS 520. • Photochemical efficiency of PSII was recorded in promising seed stocks under long term trial. Photochemical efficiency or chlorophyll fluorescence is significantly higher in St.643. • Under the *In situ* conservation programme, 10 diverse seed materials are found suitable to establish a field trial at Socklatinga tea estate. • Under clonal selection program, 14 plants have been selected out of 3590 plants from nursery of Dufflating tea estate for further evaluation. • Supplied six diverse clonal materials to the	

				Dufflating tea estate to study the nursery performance. Out of 6 planting materials, N6 is performing better in nursery.	
Biotechnology					
10. Establishment of DNA barcodes for wild and commercial tea varieties. **(New Proposal)**	Dr S Borchetia	In a inhouse experiment, we identified the ITS1 and 2 sequences between a wild and cultivated tea viz. TV1, TV25. Differences was observed in single nucleotides in the ITS2 sequences which can be a molecular target to identify different tea varieties and prepare barcodes for them. The DNA barcoding will identify tea varieties which are otherwise difficult for morphological identification. It can be used as a trade mark of a particular type of tea and also identify adulteration.	Prepare the molecular barcodes for all the commercial varieties of tea available at Tocklai	**March- June, (Q2)** • Bioinformatic analysis of tea genome for sequence identification of ITS, Rbcl and Mat K genes. • Designing of primers for ITS, Rbcl and Mat K genes. • Selection of 150 clones for identification of ITS sequence. **July-September, 2020 (Q3)** • An experiment has been set up to check whether ITS, RBCL and MatK genes will be able to identify plant samples in 15 TV clones. • DNA extraction in 15 TV clones using CTAB method. • Standardization in progress for ITS, RbCl and Mat K genes primers. **October-December, 2020 (Q4)** • DNA extraction in wild tea samples, *Camellia irrawadiensis* and *Camellia drupifera*. • PCR Amplification of ITS markers in 15 TV clones are in progress. **January-March, 2021 (Q1)** • PCR amplification of ITS and MatK markers in	Started from April 2020 - 2023

				15 TV clones completed. • Gene sequencing with Rbcl Markers completed in 15TV clones. • Bioinformatic analysis of Rbcl markers was done for sequence analysis in the 15 TV clones, calculation of genetic distance, variable sites, molecular weight of bases, amplified polymorphism, barcode development of multiple sequence alignment, use of a neighbor-joining algorithm, and tree construction analysis. **April-June, 2021 (Q2)** • PCR amplification and sequencing done for *ITS2* marker in 15 tea plant samples (TV clones and wild tea plants). • PCR amplification and sequencing done for *mat K* genes in 15 tea plant samples (TV clones and wild tea plants). **July-September, 2021 (Q3)** • DNA extraction and PCR amplification with *ITS2* markers done for 20 tea plant samples. **October-December, 2021 (Q3)** DNA extraction and PCR amplification with *ITS* markers done for 14 tea plant samples. **January-March, 2022 (Q1)** DNA extraction from popular TV clones and garden series clones and ITS PCR amplification in 31 germplasms namely TV1, TV9, TV17, TV18, TV20, TV22, TV23, TV25, TV26, TV29, TV30, TV31, TV32, TV34, TV35, HK22/14, Bormajan19, DP36, DP10, SNT9, SNT10, AV2, P312, CP1, HV39, RR17/144, S3A3, T3E3, Tinali17, T78.	

				April-June, 2022 (Q2) Matk, rbcl, psbA-trnH chloroplast gene and ITS2 nuclear gene amplification and Sanger Sequencing in 23 germplasms namely TV32, TV30, TV26, TV9, TV22, TV20, TV34, HV39, AV2, Tin Ali17, T78, S3A3, T3E3, WK/K/A, HK22/144, SNT10, S3A1, RR.17/144, Bormaajan, C. irrawadiensis, TV1, TV19, TV35, TV22(repeat), TV35 (repeat) to generate DNA barcodes in popular tea varieties.	
Biochemistry					
11. Theaflavin profiles, the formation during oxidation and correlation with Taster's Quality in CTC black tea	Dr. S. Sabhapondit	Standardization of methodology for identification and quantification of individual theaflavins using High Performance Liquid Chromatography Monitoring of the formation of individual theaflavins during oxidation under controlled environment Determination of theaflavins profile in experimental as well as commercial black tea and their correlation with tasters' quality	Standardisation of methodology for theaflavins profile Corrélation study of tasters' quality with theaflavins fractions Manipulation of process variables for higher theaflavins and thus better price realisation in CTC black tea Role of individual theaflavins to Assam CTC black tea quality	**Jan – Mar, 2020 (Q1)** Review of literature and paper works related to the project is carried out **April – Jun, 2021 (Q2)** Plan and design of experiments prepared Work on standardisation of methodology for determination of theaflavins in HPLC Delay in starting the experiment • Pandemic situation due to COVID 19 • Technical issue – ECM dryer is not working **July – Sept, 2020 (Q3)** • For standardisation and estimation of theaflavins fractions during oxidation, four individual theaflavins were extracted and purified using gel permeation chromatography. The purity of the individual theaflavins was confirmed by HPLC and LC-MS study carried out at department of chemistry, Dibrugarh University. • Using the purified theaflavins, standard HPLC	Date of start 1st April. 2020 Likely date of completion 31st Mar, 2023

				analysis was initiated to standardise the HPLC method. • Two processing experiments were carried out in ECM to study the oxidation of catechins and the formation individual TFs with cultivar TV23 & TV25. **Oct – Dec, 2020 (Q4)** • To standardise the methodology for TF estimation, 36 analysis were carried out in HPLC using standard caffeine and purified theaflavins • Three processing experiments were carried out to study the oxidation of catechins and formation of TFs during processing • Catechin estimation of 28 samples during fermentation was carried out. **Jan – Mar, 2021(Q1)** • HPLC analyses were carried out to standardize the solvent system, solvent flow volume, solvent gradient etc. • Analysis of experimental samples from the processing experiments carried out during end of last year with cultivars TV1, TV25 & S.3A/3. **April – June, 2021 (Q2)** One experiment was carried out to study on change of TF and catechin profile with fermentation time was carried out with cultivar TV1. **July – Dec 2021 (Q3 & Q4)** • Only two processing experiments were carried out during this period. • Separation and purification of TF fractions by column chromatography was tried.	

				Jan – Mar 2022 (Q1) Trials on process optimization for Theaflavins extraction using solvent partition is carried out. **April – June, 2022 (Q2)** HPLC column, flow rate etc are determined in the method development for detection and quantification of theaflavins Processing experiment (one no) to study the formation pattern of TF is carried out.	
Mycology and Microbiology					
12. Integrated management of tea diseases	Dr. S. R. Sarmah	Considerable work has also been done at TTRI on utilization of antagonistic/ hyperparasitic microbes and herbal extracts in controlling certain diseases of tea. Fungi, viz., *Trichoderma viride*, *T. harzianum*, *Beauveria bassiana*, *Metarhizium anisopliae*, *Verticillium lecanii*, *Paecilomyces lilacinus* and bacteria such as *Bacillus subtilis* were found to be potential as biocontrol agents in both laboratory and field trials. Several experimental findings, at Tocklai proved the efficacy of *B. subtilis*, in controlling major foliar disease of tea like black rot and blister blight similarly *Trichoderma* is	Exploration of more new effective biocontrol agents including microbials and herbal extracts. Popularization and recommendation of effective components in IDM schedule. Minimal use of plant protection chemicals. It reduces the residual toxicity as well as environmental hazards. Reduction of plant protection cost.	**July-September 2016 (Q3)** Bio efficacies of new fungicides have been studied against foliar diseases of tea. Various surfactants are evaluated to observe their efficacy. Study is in progress. Antagonistic microbes at different doses were also under field evaluation against black rot disease. **October-December 2016 (Q4)** Two new field experiments were conducted at Tyroon and Tocklai T.E. during 2016-17 for controlling red rust and black rot diseases of tea T. E. Different doses of microbes were also included in the black rot control experiment. Completed the treatments imposition in the areas. The trials are in progress. Thus, evaluated the efficacy of new fungicides for controlling red rust diseases of tea through field experiment at Tyroon T.E. in Mariani circle. 31-77% reduction of disease was recorded due to application	Date of start 11.04.2016 Date of completion 10.04.2019

		preventing *Poria* branch canker, thorny stem blight and primary root diseases. Actinomycetes having antagonistic behavior isolated from tea rhizosphere were also tried against common tea diseases. The aqueous extracts of commonly available herbs like *Cassia tora, C. alata, Argimon maxicana, Polygonum hemiltonii, Xanthium strumarium, Clerodendrum viscosum, Acorus calamus, Equisetum arvense, Amphineuron opulentum* etc. were also evaluated for controlling major diseases of tea and found effective up to varying degrees. These microbial biocides and herbal extracts are the effective component of integrated disease management schedule in tea in the present day context. (Barthakur et al. 1993, 1994, 2001, 2011: Sarmah et al. 2005, 2006, 2008, 2009, 2013, 2014: Dutta et al. 2005: Phukan et al. 2012).		of fungicides. Raze (COC 50% WP) @25g/10L was found effective in controlling the disease (up to 73.6%). COC recorded 77% disease reduction. Different surfactants like Activa 80, Aspa 80, Dhanuvit, Magic Shakti were also tried for their efficacy and recorded maximum 77% reduction of the disease when mixed with fungicides. The efficacy of fungicides was also evaluated against black rot diseases at Tocklai experimental tea estate. Disease reduction was achieved from 40 to 80% at different treatments. Among the treatments Raze (COC 50% WP) @ 25g/10L was found effective in controlling the disease (up to 77% reduction). Marginal increase of efficacy was recorded when surfactants was added with fungicides. This indicates the added benefits of the surfactants when applied in combination with fungicides. **January-March 2017 (Q1)** The post treatment data generation and analysis on the bioefficacy of treatments against both the experiments are under process.. **April-June 2017 (Q2)** Recorded 31-78.5 % and 35.4 to 77.4 % reduction of red rust and black rot disease respectively due to application of fungicides. *Pseudomonas fluorescens*1% WP (Phasal Rakshak) a bioproduct was also evaluated and recorded less efficacy in controlling red rust and black rot disease as compared to other chemical fungicides, at higher dose *i.e.* 50g/10L it records 48 to 45.1 % reduction of	

				the disease respectively. Microbial biocides *B. subtilis* at different concentrations (2, 5 and 10%) and *Streptomyces nojiriensis* @ 5% resulted 51.6 to 67.7 % and 64.5 % reduction of black rot disease. Artificially inoculated the root pathogens in the experimental area at Borbhatta T.E. to see the effect of *Trichoderma* on root disease protection in nursery beds. **July-September 2017 (Q3)** Three new field trials were conducted by integrating Fungicide molecules, organic based formulations such as Sesame oil and koranj oil and microbials (*Actinomycetes, Bacillus pumilus* and *B. subtilis*) in controlling diseases of tea. First field trial was laid out at Latakoojan, T.E. for controlling red rust disease. Second trial at Tocklai T.E. for controlling black rot disease and Third trial for controlling *Fusarium* die back disease at Hoolungoorie T.E. Pre treatment observation and treatment imposition are in progress. **October-December 2017 (Q4)** In the integrated disease management trial at Hoolungoorie T.E. One round of treatments were	

				applied and post treatment observation on disease intensity were recorded. The trials are in progress along with integrated field trials for controlling red rust and black rot disease of tea. **January-March, 2018(Q1)** Post treatment result on the integrated control of *Fusarium* die back disease conducted at Hoolungoorie T. E. indicates 82.9% and 65.8% reduction of disease when *T. viride* and *B. subtilis* was applied @5% cfu load respectively. The nucleotide sequences of certain effective biocides including *Trichoderma, Metarhizium, Beauveria, Bacillus* etc. were submitted in GenBank sequence database and obtained the accession number. **April-June, 2018(Q2)** The experimental findings on integrated disease management recorded 52.5-77.5% reduction of red rust disease incidence at Lattakoojan T. E. COC in combination with adjuvant showed maximum efficiency (up to 77.5% reduction) in controlling the disease. 68.9% and 65.4% reduction in disease severity was, however, observed after the plants were treated with *B. subtilis* @10% and 5% respectively. Post-treatment observation for black rot disease at Tocklai T.E. showed a reduction potential ranging from 32.7% to 80.5 % over control. Microbial strains were effective in reducing the disease intensity from 50.6%-60.3%. Among the microbials, *B. subtillis* @ 10% showed maximum potentiality (up to 62.3%) in controlling the black rot disease over control followed by 58.4% and 50.6% @ 5% and 2%	

				concentration of *Bacillus* respectively. Initiated two new field trials respectively at Kakodonga and Lakwah T. E. in a randomised plot for controlling the red rust disease. Fungicides, microbials and herbal extracts were applied as treatments. 1st and 2nd round of treatments were imposed. The experiments are in progress. **July-Sep, 2018(Q3)** Conducted a new field trial at Tocklai T. E. for controlling black rot disease exploiting an integrated approach. 1st and 2nd round of Treatment application has been completed. The experiment is in progress. For controlling red rust disease, field experiments are in progress and periodical treatments were imposed at Kakodunga and Lakuawh T.E. Post treatment observation shows improvement in bush health. **Oct-Dec, 2018 (Q4)** Post treatment observation was done on the field trials conducted for controlling red rust disease at Lukwah and Kakodonga T.E. The consortium of PGP microbes (*Azotobacter*+*Azospirillum*+PSM) showed reduction of the disease severity (up to 77.8% reduction over untreated control) followed by *T. viride* @2% SC with 71.9% reduction of disease. Against black rot disease conducted at Tocklai division, the recorded data showed the efficacy of PGP consortium (*Azotobacter* + *Azospirillum* +PSM) @2% with 74.2% disease reduction followed by	

				Trichoderma viride @2% SC (up to 71.9 % control) and *Bacillus subtilis* @2% SC (up to 68.1 % control) over untreated control. **Jan-Mar, 2019 (Q1)** Survey was made for disease incidences in tea for layout of field trials by using new generation fungicide molecules and biological pesticides. **Apr-Jun, 2019 (Q2)** Conducted four multilocational field trials for evaluation of new agrochemical products against red rust (02 trials), black rot (01 trial) and *Fusarium* die back (01 trial) disease. 1st and 2nd round of treatment application and periodical data generation are in process. Initiated two trial to assess the tainting of new fungicide molecule on made tea. **July-Aug, 2019(Q3)** Treatments were imposed consequently for 3rd and 4th round at Borbhata and Tocklai T.E. in relation to agrochemical evaluation experiments against red rust, black rot and *Fusarium* die back diseases in tea with periodical data generation. Field trial for tainting tests of new fungicide molecules on made tea was completed and process of organolaptic evaluation is in progress. **Sep-Dec, 2019(Q4)**	

				In field experiments conducted against red rust, black rot and *Fusarium* die back diseases in tea, the final post treatment observation was made and the data analysis is in progress. **Jan-March, 2020 (Q1)** One field trial has been initiated at Tocklai T.E. for evaluation of the efficacy of *Trichoderma* biocide against *Poria* Branch canker. Pre-treatment data generation and experimental lay out is in progress. **April-June, 2020(Q2)** Pre treatment assessment and treatment application was done in the Poria infected branches after proper cleaning and *Trichoderma* biocide was applied at different concentrations (@ 1%, 2% and 5% SC respectively) to observe the potential of the biocide in reducing the disease protection efficiency. A field trial has been initiated at Borbhatta T. E. for controlling red rust disease. Different fungicide molecules were tested to evaluate their efficacy in controlling the disease. First and second round of treatments were applied after pre treatment data generation. The trial is in progress. Conducted another field trial at Tocklai T. E. Sec No.16 for controlling black rot disease. Fungicide molecules were tested to evaluate their efficacy in controlling the disease. Two rounds of treatments were applied at 15 days interval after pre treatment data generation. The trial is in progress.	

				July-September, 2020(Q3) Two round of treatment were imposed in the ongoing bio efficacy trial at Borbhatta T.E. against red rust disease. Crop yield data generation is also in process for the said experiment. Periodical data generation is in progress in the ongoing black rot experimental area conducted at Tocklai T. E. **Oct-December, 2020(Q4)** Another round of treatment applications were imposed in the ongoing bio efficacy trial at Borbhatta T.E. against red rust disease. Post treatment data analysis is in progress. **Jan-March, 2021(Q1)** The post treatment efficacy was assessed for controlling red rust and black rot disease in the field experiment conducted at Tocklai and Borbhetta T.E. The efficacy of the treated chemicals recorded maximum up to 77.2% and 74.1% control over control against red rust and black rot disease respectively. **April-June, 2021(Q2)** Post treatment disease protection was assessed in the field trial conducted last year at Tocklai T.E. to evaluate the efficacy of *Trichoderma* against *Poria* Branch canker. Disease protection level, Wound Healing (WH) was more in using *Trichoderma*	

				bioformulations@10% SC (WH up to 1.7 cm) followed by 5% (WH; 1.2 cm), 2% (WH; 1.0 cm) and 1% SC (0.7 cm), respectively, as compared to untreated control. COC @1:400 showed disease healing up to 1.3 cm. Survey was made at Tocklai and Borbhetta Tea estate on the incidence of red rust infection and the infected plots were measured for their disease severity using standard protocols and selected plots were demarcated for further experimentation. **July-Sep, 2021(Q3)** Survey was done in 10 different gardens of Upper Assam on Fusarium die back infection. Disease infected samples were collected along with the soil samples. A preliminary air sampling was also done following exposed plate technique. In vitro estimation, isolation, documentation and identification of fungus in *Fusarium* infested tea twig, air sample and soil samples is in process. Microscopic and Morphological observation of the fungal colonies were initiated. Another two different gardens in Upper Assam was also surveyed on infestion with *Fusarium* die back. Disease infected samples were collected along with the soil samples and isolation of the pathogen is in progress. **Oct-Dec(8th), 2021(Q3)** Survey was done in another 5 different gardens of Upper Assam on Fusarium die back infection to study pathogen variability in *Fusarium* infected areas. Disease infected samples were collected along with the soil samples (both sub and top).	

				The fungal population of the top soil was found to be higher than the sub soil. In vitro estimation, isolation, morphological study and identification of the fungal colonies are in progress. The morphologically similar to *Fusarium* species were isolated and preserved for further study. **Jan-March, 2022(Q1)** *Fusarium* infected twig samples were collected from different T.E. of South bank region. The samples were cultured to isolate the responsible pathogenic fungi and studied their morphological colony characteristics, pigmentation and spore characters etc, Rhizospheric soil samples both top and sub were also collected from such areas and were analyzed for quantitative and qualitative analysis of their fungal populations. Some of the soil samples were also found to be the habitat of *Fusarium sp.* All the *Fusarium* strains were isolated and preserved for further study. The fungal population was recorded higher in the soil collected from Fusarium infected area. Survey was made in Borbheta experimental area for laying out a field trial against Fusarium die back disease in tea. Soil samples both top and sub were collected and were analysis for NPK and C contents is in progress. **April-June, 2022(Q2)**	

				New strains of actinomycetes were isolated from rhizospheric top soil of *Fusarium* infected areas and a laboratory trial is being carried to test their antagonistic potentiality against *Fusarium* sps. Morphologically and microscopically identified *Fusarium* species isolated from *Fusarium* die back infected twig and rhizosphere soil of infected region from different agro climatic zones are subjected to *in vitro* antagonistic screening assay with few microbial strains available in departmental microbial culture depository	
13. Isolation of potash mobilizing bacteria (KMB) and evaluation of their potentiality in nutrient management	Dr. P. N. Bhattacharyya. Mrs. M. Bordoloi	Tocklai Tea Research Institute (TTRI), Tea Research Association (TRA) has conducted some pioneering works on characterization of KMB strains isolated from tea field itself. The efficiency of the strains has been tested on nursery grown bean (*Phaseolus vulgaris* L.) plants (Tocklai Ann. Sc. Report 2014-15). The isolates were found to be capable in enhancing the available K level in soil after one month of incubation *in vitro*. KMB are known to produce aminoacids, vitamins and growth promoting substances like Indole acetic acids (IAA) and Gibberellins (Ponmurugan and Gopi 2006) and thereby plays an important role acting as plant growth promoters (PGP).	The effective potash mobilizers may reduce the dose of inorganic fertilizers and thus it would lower the overall cost of fertilizers. If dose of inorganic fertilizer can be reduced, the soil health status will improve which will substantially minimize the adverse effect of inorganic fertilizer in soil and environment. Improvement of tea bush health and productivity with the addition of	**July-September 2016 (Q3)** KMB strains have been isolated from tea and non tea area and were gram negative, rod-shaped, motile bacteria and the strains TKMB11, TKMB6, TKMB3 & TKMB8 were effective in releasing available potash in soil. Incubation study to evaluate the potentiality of the isolated strains for the release of K by using waste mica as inorganic source of potash is in progress. The strains are also under field evaluation to observe their efficacy. The four KMB strains are under molecular characterization. **October-December 2016 (Q4)** The potash mobilizing bacterial (KMB) stains were screened and out of them four strains such as KMB-3, KMB-6, KMB-8 and KMB-11 were found to be highly potential and were selected for evaluation of their potentiality as an alternative source of potash in tea cultivation through an *in* study. For this, soil samples were analyzed at periodic intervals like 30, 60, 90, 120 and 150 days after incubation for potash availability following standard procedure of Jackson	Date of start 11.04.2016 Date of completion 10.04.2019

			beneficial potash mobilizing bacteria isolated from tea soil. Studies pertaining to potash mobilizing microorganisms are also helpful to develop an integrated nutrient management (INM) schedule and thereby reducing the chemical load and residue effect to facilitate sustainable tea ecosystem	(1973). TKMB11, TKMB6, TKMB3 and TKMB8 respectively were found as effective in increasing available potash in soil. The effect was more with strain TKMB11 after 150 days of incubation period followed by TKMB6, TKMB3 and TKMB8 respectively. A field experiment was then executed to evaluate the efficacy of the potent KMB strains in reducing the potash fertilizer in tea. The experiment was laid out at Tocklai experimental area and the findings in terms of crop yield after one year indicates the maximum efficacy (up to 25.7%) of the strain KMB 6 in combination with half dose of potash. The potential strains KMB03, KMB06 and KMB08 were identified as *Bacillus pumilus* and strain KMB11 as *Bacillus subtilis* based on their biochemical as well as molecular characteristics using 16s rDNA homology. **January-March 2017 (Q1)** Potassium solubilization by the microbes were also carried out by calculating the clearing zone activity and Khandeparkar's selection ratio (zone of clearance (D)/diameter of growth (d) ratio). It was maximum in TKMB 11 (3.0 mm) followed by TKMB 6 (2.1mm) and TKMB8 (1.6 mm). **April-June 2017 (Q2)** Field experiment at Tocklai Experimental T.E. is being continued to assess the effect of potash mobilizing bacteria (KMB) in nutrient management of tea. The record on crop yield data is being taken to evaluate the efficacy on percent crop productivity. **July-September 2017 (Q3)**	

				Crop yield observation are being continued in the experimental area at Tocklai Experimental T.E. to assess the effect of potash mobilizing bacteria (KMB) in nutrient management of tea. KMB strains were applied as per the treatment schedule in the experimental area. Data indicates the potentiality of the KMB strains in increasing green leaf yield (up to 6.9 Kg) during the period. Available potash (108 ppm) was observed maximum in the KMB treatment No. 9 (MS1 identified as *Bacillus pumilus*). **October to December (Q4)** The experiment is in progress for the exploitation of KMB strains in field to evaluate the available potash in soil. There was an enhancement in percent crop gain in the KMB treated areas increasing crop yield ranging from 6.5 to 17.7 % over untreated control during the period. **January-March 2018 (Q1)** Field experiment at Tocklai Experimental T.E. is being continued to assess the effect of potash mobilizing bacteria (KMB) in nutrient management and productivity of tea. Initiated the process of generating the crop yield data for the current season. The nucleotide sequences of the effective KMB strains were deposited in NCBI GenBank and obtained the NCBI accession number.	

				April to June, 2018 (Q2) The cultural operations in the experimental plots at Tocklai T.E., for the field trial on potash mobilizing bacteria (KMB) in nutrient management of tea is done. Data generation on crop yield is being continued in the experimental plot at Tocklai T.E. on potash mobilizing bacteria (KMB) in nutrient management of tea. **July to Sep, 2018 (Q3)** Maximum crop yield (up to 41.5%) over control was recorded in the treatment where K-fertilizer was used @75% dose along with KMB strain (MS04), followed by treatment of potash mobilizer (MS02) applied in combination with reducing the doses of k fertilizers (up to 50%). Sole treatment with KMB also showed significant achievements in crop yield (maximum up to 24.1%) over control at Tocklai T.E. in ongoing experiment on KMB in nutrient management of tea. Periodical observation, treatment applications and data generation are in progress. **Oct-Dec, 2018 (Q4)** Crop record showed significant improvement in the KMB treated areas over control. Mean highest crop gain was recorded with Microbial strains 1 (50.0%) and 2 (35.1%) when application of potash was reduced to 25% and 50% respectively in the experimental plot on KMB in nutrient	

				management of tea. **Jan-Mar, 2019 (Q1)** Forking was done during this period. Initiated the process of generating the crop yield data for the current season after tipping. Another round of treatment application (a total of 17 no. of treatments) is under progress. **Apr-Jun,2019 (Q2)** Weekly crop yield data is being continued at KMB experimental plot at Tocklai T.E. One round of KMB strains were applied as treatments in the experimental area. **July - Aug, 2019 (Q3)** Periodical crop yield data is being generated in the experimental plot at Tocklai T.E. for the field trial on "Role of KMB enhancing crop yield". **Sep-Dec,2019(Q4)** Periodical data generation on crop yield is in progress from the experimental plot at Tocklai T.E. on effect of KMB in reducing the inorganic nutrient in tea soil. Enhanced crop yield was recorded due to application of potash mobilizers. Recorded enhanced crop yield due to application of microbial treatments. **Jan-March, 2020 (Q1)** The cultural operations and field cleaning activities	

				have been made in the experimental plot for evaluating the effect of KMB in reducing the inorganic fertilizers. Post treatment observation for crop gain in the microbial treated areas (% gain over control) for the ongoing season shows improved effect of microbial inoculants over control. **April-June2020(Q2)** Periodical crop yield data generation and treatment application is in progress. **July-September(Q3)** One round of potash mobilizers was imposed as treatments in the experiment for evaluating the effect of KMB in reducing the inorganic nutrient in tea soil. Crop yield data generation and data generation is in progress. **Oct-Dec 2020 (Q4)** Yearly round of potash mobilizers was imposed in the experiment for evaluating the effect of KMB in reducing the inorganic nutrient in tea soil. Maximum crop gain up to 20.9% over control was recorded with TR6 (75% K2O/ha + *Bacillus pumilus*) when fertilizer was reduced up to 25%. **Jan-March, 2021(Q1)** Imposed one foliar round of treatment of potash mobilizers in the experimental plot at Tocklai T.E. Cold weather operations are in progress in the experimental area. Initiated the crop yield data record in the area for this current plucking season. **April-June, (Q2)** The periodical data generation in the experimental	

				area is in progress. **July-Sep,2021 (Q 3)** One round of treatments were applied in the experimental area. The periodical data generation in the experimental area is in progress. **Oct-Dec, 2021(Q4)** Crop harvest and periodical data generation in respect to treatment variation and the analysis of the data is in progress. **Jan-March, 2022(Q1)** Collected soil samples from Experimental plot of Potash mobilizing bacteria at Tocklai division from different treatment areas and were sent to the soil department for physico chemical analysis, it is in progress. **April-June, 2022(Q2)** A compatibility test was carried out for existing KMB strains with *B. subtilis*, *A. chroococcum*, *A. brasilense* and their consortium and found to compatible with each other.	
14. Rhizosphere microbiology of tea soil	Mr. A. J. Tanti	The rhizosphere is the region of soil that is immediately near to the root surface and that is affected by root exudates (Kenedy 1999); it was described for first time by	Qualitative and Quantitative estimation of various PGP and antagonistic microbes in tea	**July-September 2016 (Q3)** Effect of PGP microbes on growth of tea bushes are being monitored in field in a commercial garden. The microbes are also in the process of evaluation to reduce the fertilizer dose in young tea management.	Date of start 11.04.2016 Date of completion 10.04.2019

		Lorenz Hiltner (1904). There are different types of substances that diffuse from the roots and that stimulate the microbial activity, such as carbohydrates (sugars and oligo-saccharides), organic acids, vitamins, nucleotides, flavonoids, enzymes, hormones, and volatile compounds (Prescott, Harley and Klein 1999). Microorganisms which live in close association with roots of higher plants are known as Rhizosphere microbes and much research has been carried out in relation to its plant growth and antagonistic activity (Kloepper,et al., 1980). Beneficial effects of rhizospheric microbes have been reported by various workers in a wide range of crops including cereals, pulses, vegetables, oil seeds and plantation crops (Alagawadi and Gaur 1992, Bashan and Holguin1997 and Riggs *et. al*. 2001).	rhizosphere of different tea growing zones of North East. Exploitation of the beneficial rhizospheric microbes in increasing yield of tea. Use of microbes in suppression of tea pest and diseases. Creation of microbial data bank for future utilization	**October-December 2016 (Q4)** The study is being continued since 2013-14 at Hoolungooree T.E. to determine the effect of certain beneficial PGP microbes in reducing NPK input in young tea management (YTM). Three promising PGP strains i.e. *Azotobacter chroococcum, Azospirillum brasilense, Bacillus subtilis* and their consortium were applied as soil treatment (in planting pit) and foliar spray to observe their efficacy in reduction of chemical fertilizer as well as to increase crop yield. The effect of the PGP microbes (in terms of half and full doses of YTD) were assessed by measuring the physical characteristics of the tea bushes such as girth, number of branches and plant biomass. It was observed that at half doses of NPK, *A. chroococcum* (12.34%) followed by *A. brasilense* (9.71%) treated plants showed increased girth of the plant. Maximum girth was, however, recorded with *Bacillus subtilis* (17.59%) when it was applied at full doses of NPK. In both full and half doses of NPK, *A. chroococcum* (14.77%) showed maximum increase in no. of branches. *Bacillus subtilis* was found as more effective microbe at full doses of fertilizer application. Percent gains in biomass of fresh pruning litters were also calculated. Application of *A. chroococcum* recorded maximum percent gain (124.5%) in biomass over untreated control in full doses of NPK application. *A. brasilense* recorded maximum percent gain in biomass with application of NPK at half doses over untreated control indicating the potentiality of microbes to work effectively at an environment with low soil nutrient status. Moreover, all the microbial treated plots recorded less percent mortality of the plants. Maximum crop yield was recorded with *B. subtilis* (up to 15.2% crop gain over untreated control) at full doses of NPK followed by	

				A. chroococcum (14.93%). In case of half dose of NPK maximum crop gain over control was exhibited by consortium of the three microbes (up to 14.1%) followed by *B. subtilis*. The study is in progress. **January-March 2017 (Q1)** Collected the soil samples of the different treated areas for quantification of beneficial microbes. The study will be continued on the effect of treatments in terms of crop productivity and reduction of NPK input. **April-June 2017 (Q2)** The microbial analysis of the soil samples from the experimental area on reduction of NPK inputs in young tea management at Hooloongoorie T.E. recorded 1.0 to 16.33 cfu $x10^5$/g of different beneficial group of microbes. The crop record is being continued in the experimental area to study the effect of PGP microbes in reducing NPK input in YTM. The result shows potentiality of *Azotobacter chroococcum* treated plots as compared to control. The data record and periodical observations is being continued and the study is in progress A new trial has been laid out in second location at Tocklai T.E sec no. 3 to study the effect of PGP microbes in reducing NPK inputs in young tea. Microbials *i.e.* AZR-08, AZM-10, BST and its consortium along with organic manure were applied at the planting pits during planting in a randomized block designed area.	

				July-September 2017 (Q3) In continuation to the experiment on "Reduction of NPK inputs in young tea management" at Hooloongoorie T.E. the crop record for the month of July indicates the significance of PGP microbes in increasing the crop gain in comparison to control. AZR (H) recorded maximum yield of 80 kg followed by BST (F) (67 kg) and AZM (H) (66 kg) against control (53 kg). One round of foliar treatment of PGP microbes were applied in the area. The other experiment on reduction of NPK input in young tea management (YTM) vs application of PGP microbes at Tocklai T.E. is in progress with periodical treatment application and data generation. **October to December (Q4)** In the integrated nutrient management trial at Hoolungoorie T.E., plucking record was being made. Maximum crop gain (in kg.) was recorded in the treatment AZR (H) (41.90) against control (33.56) followed by AZM (H) (38.53) and BST (F) 38.50). The associations of beneficial soil microbial populations including the presence of certain functional groups were assessed from the soil samples collected from the T. E. Maximum bacterial population was observed in consortium (F); 43.7 $X10^5$ cfu/g dry soil as compared to control (37.3 X 10^5 cfu/g dry soil). Fungal population was maximum in AZM (F); 5.5 X 104 cfu/g dry soil. Actinomycetes were recorded maximum in AZM (H); 1.5 X 10^4	

				cfu/g dry soil. *Azospirillum* was highest in consortium (H); 2.5 $X10^4$ cfu/g dry soil; while *Azotobacter* in AZR (H); 1.5X 10^4 cfu/g dry soil. Maximum phosphate solubilizers was recorded in BST (F); 1.0 X 10^4 cfu/g dry soil. The experiment at Tocklai T.E, on reducing the NPK input in young tea management (YTM) vs application of PGP microbes is being continued. **January to March,2018 (Q1)** One round of microbial treatment was applied in the experimental area. Compilation of crop yield data for the completed year is in progress. Studied the rhizosphere microflora of tea clones like S_3A_3 and TV23 at different depths. Maximum microbial population was recorded at the top soil (0-15 cm) depth, while the population decreases with increasing depths. **April to June, 2018 (Q2)** First and second rounds of microbial treatment (*Azotobacter* sp., *Azospirillum* sp., *Bacillus* sp., and consortia of the three microbials) was imposed at Hoolongoorie T.E. in the field trial on "Reduction of NPK inputs in young tea management" for the current session. The crop yield data indicates maximum crop gain from the treatment AZR (H) (42.7 kg) followed by AZM (H) (36.7 kg) over untreated control (31.8 kg). The experiment is in progress. The cultural operations in the experimental plots at	

				Tocklai T.E., for the field trial on reduction of NPK input in young tea management (YTM) vs. application of PGP microbes is being continued. **July to Sep, 2018 (Q3)** In the ongoing field trial on "Reduction of NPK inputs in young tea management" crop yield during the period has been recorded and found to be maximum in the treatment AZR (H) (83.6 kg) against control (59.1 kg). However, all the microbial treated plots showed higher yield as compared to control. Periodical observation, treatment applications and data generation are in progress. **Oct-Dec, 2018 (Q4)** In the young tea management (YTM), data showed considerable gain in crop yield when different microbes *viz. Azotobacter* sp. *(*21.9 %) , *Azospirillum* sp. (13.1%), *Bacillus subtilis* (12.2%) and their consortium (8.95%) were applied with reduced dose of YTD input. **Jan-Mar, 2019 (Q1)** The cultural operations in the experimental plots at Hoolongoorie T.E., for the field trial on rhizosphere microbiology of tea soil are under progress. 1st round of plucking has been initiated for the current cropping season. **Apr-Jun,2019 (Q2)**	

				In the experiment "young tea management using beneficial microbes" maximum crop gain was recorded in the treatment AZR (H) (37.1 kg) followed by 32 4 kg in BST (H) as compared to control (28.9 kg). One round of foliar spray with the respective microbial (*A. chroococcum*, *A. brazilensis*, *B. subtilis*) was made for the current year. The beneficial microbial population numbers in the experimental plot was assessed to observe their association trends. Maximum bacterial population numbers was observed in consortium (FD); 27 $X10^5$ cfu/g dry soil; followed by consortium (HD) (22 $X10^5$ cfu/g dry soil) as compared to control (14.5 X 10^5 cfu/g dry soil). Fungal population was maximum in BST (FD); 5.5 X 10^4 cfu/g dry soil. The available phosphate was maximum in the BST (FD) treated soil (29 ppm) as compared to control (22 ppm). The periodical treatment applications and data generations are in progress for the field experiment on reduction of NPK in young tea with PGP exploitation at Tocklai T.E. One field trial is in progress at Tocklai T.E., to standardize the inoculum potential of beneficial microbes for their use in tea. **July to Aug, 2019 (Q3)** In the experiment on young tea management using beneficial microbes, maximum average crop was recorded at treatment AZR (H) (49.2 kg) followed BST (H) (47.3 kg) as compared to 36.7 kg in untreated control for the months of July and August, 2019.	

				Sep-Dec,2019(Q4) The final data compilation on the effect of beneficial microbes in the young tea management for the year is in progress under the field experiment conducted at Hoolungooriee T E , Data generations on yield of tea are in progress for the field experiment on use of PGP microbials at Tocklai T.E. **Jan-March, 2020 (Q1)** Crop yield was enhanced in the young tea management experiment using beneficial microbes at Hoolungoorie T.E. Maximum crop gain (%) was recorded in the plants treated with BST (HD) (29.7%) followed by AZM (HD) (28.9%) and AZR (HD) (20.7%) respectively over control. Among FD treatments, highest crop gain was recorded when the plants were treated with BST (FD) (20.7%) followed by Cons. (FD) (14.5%) and AZR (FD) (13.9%) respectively. Soils of the microbial treated plots (Hoolungoorie T.E.) shows presence of beneficial microbes. Maximum microbial populations were recorded in the PGP treated areas against control. Highest bacterial populations were observed in AZR (H) treated areas (28×10^5 cfu g^{-1}) followed by AZR (F) (20.7×10^5 cfu g−1) and Consor (H) (20.3×10^5 cfu g^{-1}) treated areas respectively. Total fungi and mold population was highest (15.7×10^5 cfu g−1) in AZM (H) treated areas. Similarly, more number of functional categories of microbes (phosphate solubilizers,	

				nitrogen fixers) was estimated in the microbial treated areas than untreated control plot; where no inoculums has been added additionally in soil. AZR (H) treated areas showed maximum Av. N up to 106 ppm, Av. P_2O_5 (up to 21 ppm), and Av. K_2O (up to 221 ppm) against untreated control. **April-June2020(Q2)** To standardize the concentration of PGP microbes in crop gain, one field experiment has been designed at Tocklai TE to observe the efficacy of growth promoting microbials like AZR, AZM and BST along with their consortium @ 1%, 2% and 5% SC. 1st round of treatment application was done in the area. The trial is in progress. **July-Sep 2020(Q3)** Periodical data generation on crop yield is in progress in the experiment at Hoolungoorie T.E. on reducing the NPK inputs in young tea management and second round of treatments of PGP microbes as foliar spray was applied. The maximum crop gain for the quarter was reported in *Bacillus subtilis* (H) (83.2 kg), *Azotobacter chorrochum* (H) treated plot (up to 80.0 kg) against untreated control (63.6 kg). The percent gain in crop against control was assessed and observed maximum increase in case of *B. subtilis* (H) (30.8%) followed by *Azotobacter chorrochum* (H) (25.7%) Another round of PGP microbes @ 1%, 2% and 5% were applied at Tocklai T.E. to observe the effect of different microbial concentration on crop yield and bush health. Crop yield data generation is in progress.	

				Oct-Dec 2020 (Q4) In the YTM experiment at Hooloungoorie T.E., two rounds of treatments were applied during this period and crop yield data record has been continued. Soil samples from each treatment area including control were collected for further analysis. After compilation of crop yield data during the entire plucking period i.e., 2019-2020 the record reveals that despite reduction of NPK the percent gain of crop over control is highest in case of BST (H) i.e., 34% followed by AZR (H) up to 30.9% and Cons. (H) up to 25%. **Jan-March, 2021(Q1)** The estimation of different functional group of microbes from the soil samples in the YTM experimental area conducted at Hoolungoorie T.E. in respect to treatment variation is in progress. Soil samples from different treated area of the YTM experiment at Hoolungoorie T.E. were collected for chemical analysis to evaluate their NPK and carbon content along with the pH of the soil samples. The work is under progress Weeding and tipping operations were done in the treated area. Initiated the crop yield data record in field experiment at Tocklai T.E. i.e. effect of inoculums density of PGP microbes on crop yield. **April- June ,2021(Q2)** One blanket round of *Trichoderma* and 1st round of foliar treatment of PGP microbes was applied in the field trial on PGP vs young tea management,	

				conducted at Hoolungoorie T.E. Periodical data generation on crop yield during the period revels that treatment *Bacillus subtilis* (F) (21.6 kg) recorded maximum yield followed by *B. subtilis* (H) (19.4kg) and Azotobacter chroococcum (H) (19.2 kg) as compared to control(16.5 kg). **July-Sep,2021(Q3)** In the young tea management field experiment with PGP microbes at Hoolungoorie T.E., periodical data generation on crop yield during the period July to Sep,2021 revels that the maximum crop yield in treatment of the consortium of microbes (H) (220.5 kg) followed by 216.6 kg in *Bacillus subtilis* (H) and (216 kg) *Bacillus subtilis* (F) as compared to control (164.0 kg). Another round of foliar treatment of PGP microbes was applied in the experimental area at Hoolungoorie T.E. **Oct- Dec,2021 (Q 4)** Applied one round of microbial treatments in the young tea management field experiment with PGP microbes at Hoolungoorie T.E. During the period significant crop gain (36.5 % over control) was observed in treatment *Bacillus subtilis* (F) where normal dose of fertilizer was applied, followed by 21.8 % in treatment of microbial consortium (F). In the treatments where half dose of fertilizer was applied crop gain over control was observed in *Azotobacter chroococcum* (H) @ 24.9 % followed by *B. subtilis* (H) @21 %. Soil samples from the experimental are was collected and send for its chemical analysis in respect to	

				treatment variation. Cold weather operations in the area is in progress. **Jan-March, 2022(Q1)** Quantitative analysis of soil microbial population was done in the experimental plot of Hoolungoorie T E. Data recorded maximum bacterial population in treatment AZR(F) with 22.0 x 10^5 cfu/gm followed by 21.3 x 10^5 cfu/gm in consortium(H) while the bacterial populations in untreated control was found to be 18.3 x 10^5 cfu/gm. In case of fungal colonies maximum load was observed in the treatment BST(H) with 12.0 x 10^4 cfu/gm in comparison to control with 7.3 x 10^4 cfu/gm. Initiated crop harvesting data generation in the treated plots and one blanket round of Trichoderma @ 2% was applied. **April-June, 2022 (Q2)** One round of *Trichoderma* for boosting bush health and first round of PGP microbes have applied in the experimental plot. Soil samples from the experimental plot of Holongoorie T. E. have also been collected for analysis of microbial population dynamics	
15. Exploitation of beneficial tea endophytes for sustainable tea cultivation	Dr. S. R. Sarmah	Scientific information on the use of endophytes in tea is still in a budding stage and their uses must have tremendous benefits. Nath et al. (2015) evaluated the plant growth promoting abilities of endophytic fungi isolated from	1. The effective endophytic microbes may reduce the pesticide input and thus it would lower the	**Jan-March 2020 (Q1)** Isolated eleven nos. of endophytic microbes (7 bacteria; 4 fungi) associated with tea plants based on their cultural characteristics. Five of the isolates showed phosphate solubilization and zinc solubilization potential.	2020 March -2023

in Assam. **(New Proposal)**		tea (*camellia sinensis*) shrubs of Assam, India. Isolation and preliminary screening of tea endophytes against certain tea pathogens like *Pestalozzia theae*, *Sphereostilbe repens* and *Fusarium solani* has been made by Bora and Barthakur (2013). The workers identified the endophytic isolates based on their colony morphology and further examination of their spores and fruiting bodies using stereo and light microscopes. In recent times, studies on endophytic microbial populations in tea have received extensive attention both at laboratory as well as field evaluation. Field evaluation of the endophytic microbial populations isolated from different agro climatic regions and their bio-efficacy against the target pathogens of tea is an urgent need.	overall cost plant protection. 2. It will help in improving soil health status which will substantially minimize the adverse effect of inorganic fertilizer in soil and environment. 3. Improvement of tea bush health and productivity with the addition of beneficial endophytic microbes isolated from tea. 4. To develop an integrated disease management (IDM) schedule and to facilitate sustainable tea ecosystem.	**April-June2020(Q2)** The microbes when tested for phosphate and zinc solubilizing abilities one isolate, EF3 shows positive results. Endophytic strains were screened for antimicrobial properties against tea pathogen, *Pestalotia theae*. The highest percentage of antimicrobial activity was found in fungal endophytic strain (EF3) isolated from leaves. As per the guidance of the SAC Committee, communication was made with Dr. A. Ghosh, Bose Institute, Kolkata. Due to the current situation, the process gets delayed. **July-September (Q3)** Maximum endophytic strains were recovered from leaf samples (up to 38.88%) followed by stem (27.77%) and root (16.66%) respectively. Seven bacteria and four fungus were isolated based on their colony characteristics. Most of the bacterial isolates are gram positive in nature. Out of all the isolates, 02 fungal and 02 bacterial endophytic strains showed their potential against *Pestalotia theae*. The highest percentage of antimicrobial activity (up to 93% inhibition of the test pathogen) was found in fungal endophytic strain (EF3) isolated from leaves followed by EF4 (88.22%) and EB1 (85.22%) respectively. **Oct-Dec 2020 (Q4)** Screening for potent endophytic strains is in progress.	

				Jan-March, 2021(Q1) *In vitro* maintenance of endophytic cultures was made for further experiments. **April- June, 2021(Q2)** Screening of the endophytic microbes is in progress. The suitable culture medium was screened and Tryptic Soya Agar (TSA) was found to have more number of populations then Sabouraud Dextrose Agar (SDA) medium. Strain EF1 showed maximum colony dameter upto 4.5 cm. **July-Sep,2021(Q3)** Evaluation of the endophytic microbes against tea pathogen is in progress. The isolated strains were cultured and purified for further study. **Oct-Dec,2021(Q4)** The studies on the morphological characteristics of the strains are in progress. **Jan-March, 2022(Q1)** The process of purification of the isolated strains and the studies on the morphological characteristics are in progress. April-June 2022(Q2) Purity of endophytic strains was maintained through sub culturing of isolated microbes for further studies.	
16. Biocon version of tea	Dr. P. N. Bhattach aryya	Bio-conversion of organic wastes for their recycling in agricultural sector for	Unfortunately, much of the cellulosic materials	**Jan-March, 2020 (Q1)** Isolated twelve nos. of cellulose degrading microbes (02 fungus, 02 actinomycetes and 09 bacteria) from	2020 March -2023

ecosystem biomass to quality organic manure by utilizing the potential of efficient cellulose degrading microbes (CDMs) and earthworm species for improving soil health and crop productivity **(New Proposal)**		improving the strength of organic nutrients is a most demanding approach (Rajkhowa and Manoj-Kumar 2013) since last few decades, as to reduce and tighten the process of exploiting toxic chemicals that eventually results huge detrimental effects on the environment through physical, chemical and biological deterioration of the cultivable land (Pretty and Bharucha 2014; Bhattacharyya and Sarmah 2018) as well as affecting the non-target organisms including human-beings. Microorganisms play an important role in the recycling of agricultural wastes. Exploiting and utilizing efficient CDM and earthworm species as the potent decomposer of organic materials is, considered as suitable technology (Monroy et al. 2009).	in and around the tea ecosystem are never utilized properly in major tea growing countries like India, resulting loss of this renewable source of energy for efficient recycling of nutrients in soil. Bio-conversion of organic residues for proper recycling in tea sector for improving the strength of organic nutrients is an urgent need since last few decades, as to reduce and tighten the process of exploiting toxic chemicals that eventually load huge detrimental effects on environment through physical, chemical and biological deterioration of the cultivable land as well as affecting	different environmental sources like cow dung, vermicompost and decomposed organic matter. Confirmatory tests of hydrolysis shown clear activities by the isolated strains exhibiting hydrolysis capacity (HC) value. **April-June2020(Q2)** A pot experiment has been designed to evaluate the efficacy of cellulose degrading microbes (CDMs) in biodegradation of organic wastes. Potent worm species, *Eisenia fetida* was also added along with the CDM strains in one of the treatments to observe the dual inoculation affect of the organisms in biodegradation. Pre and post treatment data analysis for N, P, K and microbial populations are in progress. As directed by the Chairman, SAC, required information on the project has been gathered and reviewed. **July-September (Q3)** In the bioconversion experiment using cellulose degraders, significant achievement was obtained in the analysed physico-chemical properties like N (up to 1.10%), P (up to 0.60%) and K (up to 1.25%) in the treatment V (PB+CD+CDM+EW) with polylining in the pit against control after 60 days of bioconversion process. **Oct-Dec 2020 (Q4)** Laboratory isolation for novel cellulose degrading microorganisms is in progress. **Jan-March, 2021(Q1)** One new look-see field experiment is being	

			the non-target organisms including human-beings. Kinetics in organic matter decomposition using the efficient strains of cellulose degraders and earthworms have perspectives to develop alternative strategies for safe and faster decomposition of various tea ecosystem biomasses such as plant stalks, waste shade tree tops, weed biomass, pruning litter into quality organic manure which would eventually helps in reducing the load of inorganic supplements in tea ecosystem.	conducted to observe the efficacy of CDM consortium in decomposition of pruning litter over untreated control. The experiment is in progress. Performed one experiment to observe the growth and vigor of CDM consortium using 2.22 kg jaggery in 200L water tank as potent nutrient source. Full microbial growth was observed after 96 h of incubation. The consortium was applied @5% SC in tea soil to observe the microbial efficiency in reducing soil compactness. The experiment is in progress. Another experiment is continued with Soils Dept., to observe the efficacy of CDM decomposition in tea waste. CDM consortium is mixed with tea waste and another set is maintained as untreated control. The experiment is in progress. April-June,2021(Q2) One field experiment was conducted to observe the efficacy of Cellulose degraders in affecting soil compactness (to be calculated by measuring the bulk density of soil) at Latekoojan T. E. The experiment is in progress. Growth of CDM consortium in open chamber/tanks was tested and vigorous growth of CDM consortium along with *Trichoderma* sp. was observed after 96 hours of inoculums. Co-inoculation of earthworm species and CDM enhanced the decomposition of plant biomass. Microbial populations including those likes' cellulose degraders, phosphate solubilizers and nitrogen fixers of the compost increased after biodegradation. Experimentation of decomposition of tea waste using	

				CDM consortium along with potent worm species is in progress. **July-Sep,2021(Q3)** The process of purification and sub culturing of the isolated strains are in progress. **Oct-Dec, 2021 (Q4)** One commercial CDM sample was cultured in the lab to isolate and obtain the strain in pure form for further experimentation. **Jan-March, 2022(Q1)** DNA extraction from all the bacterial samples and PCR amplified with 16S universal primers for identification of the strain is in progress. **April-June, 2022 (Q2)** Sub culturing of cellulose degraders have also been done for further studies.	
Entomology					
17. Up gradation, Enrichment of Integrated Pest Management Package for tea Thrips (*Scirtothrips dorsalis* Hood) and	Dr. Azizur Rahman	Work done at recent past revealed that Yellow sticky trap is a very good alternative method for monitoring and control of thrips and green fly in field condition.	Thrips and green fly is becoming a serious concern in many tea estates, which is found difficult to manage with only pesticide application. So along with chemical pesticide other alternative methods are to be integrated in judicious manner	**April-June, 2020 (Q2)** Excessive growth of the plucking table took place during the lock down period, so a LOS was given to the experimental plot to maintain a uniform plucking table and height. The section was found infested with thrips, green fly and tea mosquito bug, For monitoring the section all shade tree trunks were lined with yellow sticky polythhene sheet and the vacant shade tree areas were installed with yellow and blue glue pad. Observation on thrips and green fly trapped to the different sticky trap was taken at weekly interval up to one month. Spraying of one round thiomethoxam was given to control tea mosquito bug. **July-September (Q3)**	Date of start: 01.02.2020 Likely date of completion: 31.01. 2023

the green hopper (*Empoasca flavescens* Fabricius): two upcoming major pest of tea in North East India **(New Proposal)**			to achieve a better control over these two pests.	A trial was initiated against tea thrips using sesamite in the field. Two rounds of spraying were done at 7 days interval. Observations were made at 7days interval up to 4th week. Study revealed a reduction of 47-57% thrips population during the period. **October-December (Q4)** Due to the non availability of Thrips and green fly further work cannot be done. **Jan-March, 2021** Plot selection and layout of the experiment in the Borbhetta experimental tea estate have been completed. Waiting for required population of the pests for field evaluation. **April-September, 2021 (Q2, Q3)** Field trial could not be continued due to Covid pandemic situation. **October-December (Q4)** Monitoring the experimental site is being continued for thrips and jassids population .However, due to lack of sufficient population, treatments could not be imposed. **January-March, 2022 (Q4)** A laboratory experiment was initiated to evaluate the synergistic action of MAK ADJUVOL as an adjuvant with recommended pesticides molecules against tea thrips and jassids.	

				One field trial was also initiated at Borbhetta experimental tea estate to evaluate the efficacy of deltamethrin 11% EC and a combination product, (tetraniliprole + spirotetramat) against tea thrips. **April to June, 2022 (Q2)** A thrips bioassay was performed in the laboratory using Quinolphos and MAK ADJUVOL. A field trial to evaluate the efficacy of MAK ADJUVOL as an adjuvant with recommended pesticide against thrips has been completed in Dalowjan, T.E. Three laboratory bioassays, each consisting of three different concentrations of entomopathogenic nematode (EPN) against thrips, have been completed. Field trial in Dalowjan T.E (Golaghat, Assam) to evaluate the efficacy of entomopathogenic nematode (EPN) against thrips has been done	
18. Extraction, Isolation and evaluation of Pheromones of major looper Pests of Tea- *Hyposidra talaca* Walker and	Dr. Azizur Rahman	Before this no work has been done at Tocklai on the pheromone of looper.	After identification of pheromone compound a pheromone trap can be developed for monitoring and control of looper pest of tea.	**April-June, 2020 (Q2)** For collaboration Contacted Dr. B.V.Subba Reddy, Sr Prinscipal Scientist, Head, Center of Semio Chemicals, Indian Institute of Chemical Technology Hyderabad. He agreed upon and forwarded the matter to business department to make an MOU. I have submitted the MOU draft to SAC chairman for necessary action.Solvent extraction and volatile extraction will be done in our laboratory so,mass culture of looper, *Hyposidra talaca* has been initiated in laboratory condition for the extraction of pheromone **July-September (Q3)** **Wind Tunnel Test: *Hyposidra talaca*** Date of start: April, 01.01.2020 Likely date of completion: 31.12.2022

Buzura suppressaria Guen for the Development of Pheromone Based Management Strategy. **(New Proposal)**				Behavioral tests were carried out by using a wind tunnel (90x36x36 cm) during scotophase period (dusk) with 5 lux (light intensity) at room temperature and humidity. The airflow was produced by an electrical fan. As the male moth of *H. talaca* set free from the cage it sensed for a second by protruding antennae towards the odor source and started frequent beating of wings than showed a zigzag upwind flights in the wind tunnel and exhibited significant response levels to odor source (Female moth). However, the upwind flights observed to be completed by 2/3 drop, it took 35-40 seconds time to reach close to the source, landed and attempted to copulate at the source of virgin female were observed. For each occasion attraction of 80- 100 % male moths were observed in case of abdominal tip extract, whereas 40-60 5 attractions was recorded with virgin female used as odor source. For control upwind flights to the treatment were not observed. So it can be assumed that the behavior of males influenced by females releasing sex pheromone. For control no such flying behaviour were observed. Y-tube Test: Experiments conducted with *Hyposidra talaca*, by usinf a T-tube to identify the response of sex pheromone in live adults. In each set of experiment, single male and single female moths were used, the female kept in right arm of the Y tube and the left arm was kept as blank	

				(without moth).One male was released in the steam of Y tube, After releasing the male moth it started fanning it's wings rapidly and proceeded to the arm containing the female moth as odor source with a zigzag movement and entered into the arm containing female moth. This indicates the possibility of sex pheromone released by the female that attracted the males. The experiment was replicated for three times. Wind Tunnel Test: *Buzzura suppressaria* Behavioral test with odor source of live female moths and solvent (hexane) extract of different body parts of female moth of *Buzzura suppressaria* were carried out with a wind tunnel (90x36x36 cm) in laboratory condition. Different body parts used were i.e. Thorax, wings, whole abdomen and abdominal tips. The observations of the upwind flights of *B.suppressaria* in the wind tunnel showed that males exhibited significantly higher response levels to the extract of abdominal tips than to the extract other body parts and control. Only the take-off rate was similar when the source was either a virgin female or the extract of abdominal tip. However, the upwind flights, flights close to the source, landing rates and attempts to copulate at the source were significantly greater for the abdominal tip extract than for the virgin female. Non upwind flights to the extract of thorax , wings and control treatment were observed. For each occasion attraction of 80- 100 % male moths were observed for the abdominal tip	

				extract, whereas 40-605 Attraction were exhibited by virgin female used as odor source. For control upwind flights to the treatment were not observed. So it can be assumed that the behavior of males influenced by females releasing sex pheromone. For control no such flying behaviour were observed. **October –December (Q4)** Solvent extraction of different body parts i.e. Head, Thorax, Wing and abdominal tip of *Hyposidra talaca* and *Buzzura suppressaria* has been completed and now samples are ready for sending to Chemical laboratory for molecular identification. (4 nos. of objectives are completed, 3 remaining) New external project will be sanctioned on the same tropic. **The project** "Isolation, identification and synthesis of pheromones of major looper pest of tea *Hyposidra talaca* Walker for the development of pheromone based management strategy[41584]" submitted under the DBT-Chemical Ecology Call has sanctioned for funding with sanction number :**BT/PR41584/NER/95/1728/2021**.The project will be done in collaboration with National Chemical Laboratory,Pune.	
NBRRDC					
Plant Physiology & Breeding					
19. Developm ent of	Dr. Buddhadeb Das	• Hybridization / Development of Region specific biclonal seed		Status up to March, 2021 • Total 34 numbers of bi-clonal hybrids are	Long term trial, continuous

region specific superior planting materials	buddhadeb das@yahoo.com	stocks • Development of Region specific clones		developed at NBRRDC which are being evaluated for seed production, compatibility features. • Biclonal combinations (L56 X HP12, TT22 X L9/34, TA17 X BJ19, B5/63 X BJ5, TV20 X S.3A/3, CB38 X B5/63, TA17 X TV26, BJ5 X TV19, HB19 X BJ19, TV14 X TV17, TV1 X S.3A/3, R2 X T383, R2 X T78, R14 X AV2, P1404 X B157, P1404 X AV2, R2 X AV2, SS6 X CB38, TV20 X TT22, BJ5 X L/51, TV1 X TV14, TV26 X S.3A/3, TA17 X CB38, TV14 X HP12, TV26 X GT30, TA17 X AV2, L/51 X BJ5, L9/34 X TV19, TV19 X CB38, TV20 X L9/34, TV20 X SS42, TV26 X BJ19, TV18 X L/51, TV20 X P1258) • Total no of long term trials under NBRRDC are five. 2nd pruning cycles in some trials are continuing. More than 5 clones are found to be promising. Status March, 2021 to June 2021 • Total 34 numbers of biclonal hybrids are developed at NBRRDC which are being evaluated for seed production, compatibility features. The experiment is being continued • Biclonal combinations (L56 X HP12, TT22 X L9/34, TA17 X BJ19, B5/63 X BJ5, TV20 X S.3A/3, CB38 X B5/63, TA17 X TV26, BJ5 X TV19, HB19 X BJ19, TV14 X TV17, TV1 X S.3A/3, R2 X T383, R2 X T78, R14 X AV2, P1404 X B157, P1404 X AV2, R2 X AV2, SS6 X CB38, TV20 X TT22, BJ5 X L/51, TV1 X	process, 2nd pruning cycles of some long term trials will be completed by 2023-24.

				TV14, TV26 X S.3A/3, TA17 X CB38, TV14 X HP12, TV26 X GT30, TA17 X AV2, L/51 X BJ5, L9/34 X TV19, TV19 X CB38, TV20 X L9/34, TV20 X SS42, TV26 X BJ19, TV18 X L/51, TV20 X P1258) • The five long term trials under NBRRDC are five. 2nd pruning cycles in some trials are being continuing. The trials have been monitored **July to December, 2021** • In an ongoing long term trial at Lakhipara tea estate 2 clones exhibited promising yield, at per quality and more degree of drought tolerance in comparison and 2 controls clones. Cuttings of these clones from long term trials plot of Lakhipara T.E. were sent to commercial tea estate for evaluation. • In long term Trial 1 at NBRRDC the selections under study, Soongachi 38, Soongachi 8, Kalabari 26, Gopalpur 16, Soongachi 28, Soongachi 1, Gopalpur 15 and Tenali 17 (control). Out of the 21 clones under trial, yield data of 13 clones viz (Chalsa 13/N/9, Kalabari 32, Kalabari 29, Kalabari 34, Ghatia 84, Soongachi 43, TV1, Gopalpur 6, Ghatia 60, S.3A/3) was not considered due to high mortality/ vacancy %. • In long term Trial 2, selected clones under study, Soongachi 4, Chalsa 5, Banarhat 31, Kalabari 14, Kalabari 30,Kalabari 33, Ghatia 86, controls (S.3A/3,TV1, TA17)Out of the 16 clones, yield data of 6 clones viz (Soongachi 11, Soongachi 7,	

				Chalsa 19, Chalsa 23, Soongachi 18, Soongachi 34) was not considered due to heavy mortality in the experimental plot. Among the afore side entries, clones having better quality in comparison to control will be used in future hybridization programme. • Apart for the abovementioned trials, there are more ongoing long term trials under NBRRDC which are being monitored as per the planting material development protocol. • Clone 107/17 found suitable for manufacturing good quality CTC tea. The trial on its yield potential is in progress. • Visited Taipoo TE Terai to assess the performance of TV 34 and TV 35. The recovery after pruning was very good in both of the clones; however it was slightly better in TV 35. **January to March, 2022 (Q1)** • Nursery performance of the following biclonal seed stocks was evaluated at Chalouni Tea Estate. St 673, St 668, St 667, St 643, TS 560 and Danguajhar Tea Grden seeds. • Identified seven early flusher tea germplasm from Sec 5A Zurrantee *In situ* seeds trial plot at New GlancoTea Estate. • Second round spray of salicylic acid under assessment of salicylic acid for drought stress management under NTRF project in Doars was completed. • Visited Chilouni T.E. Gandrapara T.E. and Danguajhar T.E. Soongachi T E, in relation to seed barie.	

				April to June, 2022 • Observations on Long Term Trials are in pregress • Recorded physiological data of some promising clones at NBRRDC and Lakhipara TE. • Recorded physiological data of the Salicylic acid trial at NBRRDC	
Entomology					
20. Augmentation and inundative release of a new reduviid predator, *Sycanus collaris*, for the management of two major tea pests *Hyposidra talaca* and *Helopeltis theivora*: An innovative biological approach **(New Proposal)**	Dr. Bhabesh Deka	In the tea ecosystem of Dooars and Darjeeling regions of West Bengal among different *Sycanus* species of Reduviidae family of order Hemiptera only *Sycanus croceovittatus* (Dohrn) have been reported (Das *et al.*, 2010 and Mitra *et al.*, 2018). The sequential predatory behaviour of the Genus *Sycanus* on its prey is very active (Ambrose, 1999). Sahayaraj, (2012) developed a rearing technique of reduviids using meat-based artificial diets which could be useful for mass rearing and pest management programme.	To develop biological control technology by mass rearing and field release of a new reduviid predator, *Sycanus collaris*, using an alternate host *Corcyra cephalonica*, which can bring down population of tea mosquito bug *Helopeltis theivora* and tea looper, *Hyposidra talaca* besides reducing several rounds of synthetic pesticides application on tea which in turn will help the planters to produce pesticide free tea	**Mar- June 2020 (Q1)** Collected *Sycanus collaris* from the tea fields and *Corcyra cephalonica* from Uttar Banga Krishi Viswavidyala. Standardization for mass culture of study insects under laboratory conditions is in progress. **July-Sept (Q2):** • Maintained the culture of *Corcyra cephalonica* and *Sycanus collaris* under laboratory conditions. • Males and females of *S. collaris* kept together to ensure mating and eggs laid were transferred for maintain the culture. • The culture of *S. collaris* was maintained by providing termite as alternate host as per the suggestions by the mentors. • Field released 60 pairs of *S. collaris* in Jiti Tea Garden, Dooars. • Study on the life table parameters of *S. collaris* under laboaratory conditions are in progress. • Validation of predatory potentiality of *S. collaris* on different pest of tea viz. *Helopeltis theivora* (tea mosquito bug) and *Hyposidra talaca* (looper) under laboratory conditions are in	**Date of start:** March 2020 **Date of Completion** : April 2023 Total Budget: Rs.1.00 lakhs No fund received as on 13th July, 2020

			for export.	progress. Status up to March, 2021 • Maintained the culture of *Corcyra cephalonica*and *Sycanus collaris* under laboratory conditions. • Maintained the culture of *Sycanus collaris* using termite under laboratory conditions. • Males and females of *S. collaris* kept together to ensure mating and eggs were transferred properly for maintain the culture. • 2 clutches of eggs were hatched. Maintained their culture. • Study on the life table parameters of *S. collaris* (for F1 generation) under laboratory conditions are in progress. • Validation of predatory potentiality of *S. collaris* on targeted pests under laboratory conditions are in progress. **March, 2021- June 2021** • Maintenance of the culture of *Corcyra cephalonica*and *Sycanus collaris* under laboratory conditions being continued. • Maintenance of the culture of *Sycanus collaris* using termite under laboratory conditions being continued. • Several clutches of eggs were hatched. Maintained their culture. • Study on the life table parameters of *S. collaris* (for F1 generation) under laboratory conditions are being continued. **July, 2021-December, 2021 (Q4)**	

				• Laboratory maintained *S. collaris has been released* in two different tea gardens for establishment. • Culture of *Corcyra cephalonica* and *Sycanus collaris* under laboratory conditions being continued. **Jan 2022-March 2022 (Q1)** • Maintained the culture of *Sycanus collaris* using termite under laboratory conditions. • Construction of life table of *S. collaris* under laboratory conditions (for Season II) is in progress. • Study on seasonal abundance and bio-ecology of *S. collaris* in two different locations (for Year II) is in progress. **April-June 2022 (Q2)** • Maintained the culture of *Sycanus collaris* using termite under laboratory conditions. • Construction of life table of *S. collaris* under laboratory conditions (for Season II) is in progress. • Study on seasonal abundance and bio-ecology of *S. collaris* in two different locations (for Year II) is in progress. • Preparation of manuscript to publish the research findings are in progress.	
Mycology and Microbiology					
21. Rhizosphere Microbiology of Tea of Dooars & Darjeeling regions **(New**	A. Tanti-PI A.K. Pandey-Co-PI	New project	▪ Isolation, identification, characterization and qualitative and quantitative analysis of various plant growth	**March – June 2020** • Protocol for the isolation of beneficial microbes from the rhizospheric soil sample was developed • Total 10 soil samples from the tea rhizosphere of 4 tea estates namely Indong, Goodhope, Dalgaon and Aryaman of Dooars region were analyzed by serial dilution method for the isolation of	March 2020 to February 2023 Total Budget: Rs.11.00lakhs

Proposal)			promoting and antagonistic microorganisms from tea rhizosphere of different zones of Dooars & Darjeeling. ▪ Exploitation of the beneficial rhizospheric microbes for increasing tea production and for suppression of pests and diseases. ▪ Popularization of the mass production technology of effective beneficial microbes.	beneficial microbes. • Four isolates of *Trichoderma* species, 4 isolates of *Pseudomonas* species, 3 isolates of *Bacillus* species, 4 PSBs, 4 isolates of *Azotobacter* species, 2 isolates of *Aspergillus fumigatus*, 2 isolates of *Azospirillum* species were isolated from tea rhizosphere soil. Confirmation of these isolates through morphological and biochemical techniques is in progress. • The pathogenic isolates of *Pestalotiopsis* species and *Fusarium solani* associated with respective grey blight and *Fusarium* shoot dieback from each tea estate were isolated and identified by cultural and morphological characteristics. The isolates were preserved for future experiments. • A review article on "How global tea industries cope up with fungal diseases? Challenges and opportunities by AK Pandey, GD Sinniah, A Babu and A Tanti was compiled and submitted to Plant Disease. **July-sept, 2020 (Q3):** • Total 8 soil samples from the tea rhizosphere of 4 conventional tea estates, namely Newland, Dalsingpara, Kurti, and Aibheel tea estates of Doors region were analyzed by serial dilution method for the isolation of antagonistic/entomopathogenic bacteria and fungi, N-fixers, P-solubilizers and actinomycetes. • From the respective tea estates, the pathogenic	No fund received as on 13th July, 2020

				isolates of *Pestalotiopsis* species and *Fusarium solani* associated with respective grey blight and *Fusarium* shoot dieback were isolated and identified by cultural and morphological characteristics. The isolates were preserved for future experiments. • From the collected soil samples 5 isolates of *Trichoderma* species (antagonist), 3 isolates of *Aspergillus fumigatus* (antagonist), 3 isolates of unknown *Aspergillus* species (antagonist), 4 isolates of *Pseudomonas* species (antagonist), 2 isolates of *Bacillus* species (antagonist), 4 PSBs, 10 isolates of PSF (*A. ochraceus, A. fumigates*), 2 isolates of unknown PSFs, 2 isolates of actinomycetes, 4 isolates of *Azotobacter* species (N-fixer), and 1 isolate of *Azospirillum* species (N-fixer; Kurti) were isolated from tea rhizospheric soil. No beneficial bacterial species reported in Aibheel tea estate. Confirmation of these isolates further through morphological and biochemical techniques is in progress. Status up to March, 2021 • Soil samples from the 10 and 40 years old tea rhizosphere of conventional (Jiti) and organic (Kumai) tea estates were analysed for presence of *Trichoderma, Bacillus, Pseudomonas, azospirillum, Azotobacter*, P-solubilizes, actinomycetes, and other soil microbes by the serial dilution method using different selective and differential media. • Evaluation of isolated *Trichoderma* and	

				aspergillus species from each tea estate against *Fusarium* sp. by the dual culture technique in order to get the potential ones. The efficacy of *Trichoderma* was compared with three plant extracts and evaluation of their mixed application is in progress. • The antagonistic activity of isolated bacteria against *Pestalotiopsis* species and *Fusarium* solaniis in progress. **March, 2021 -June 2021** • Soil samples collected from the tea rhizosphere of conventional (Jiti) and organic (Kumai) tea estates were analysed for presence of *Trichoderma*, *Bacillus*, *Pseudomonas*, *azospirillum*, *Azotobacter*, P-solubilizes, actinomycetes, and other soil microbes by the serial dilution method using different selective and differential media has been completed. • Evaluation of isolated *Trichoderma* and *aspergillus* species from each tea estate against *Fusarium* sp. by the dual culture technique in order to get the potential ones. The efficacy of *Trichoderma* was compared with three plant extracts and evaluation of their mixed application is being continued. • The antagonistic activity of isolated bacteria against *Pestalotiopsis* species and *Fusarium* solaniis being continued. **July, 2021-December, 2021**	

				• Field evaluation of bacterial antagonist and *Trichoderma* against Fusarium dieback, gray blight and red rust at Jiti tea garden (applied at 15 days of intervals). • Molecular characterization of antagonists is in progress. **Status Jan 2022- March 2022** • Molecular Characterization of potential antagonists and blast analysis • Evaluation of bacterial isolate(s) and *Trichoderma* against Fusarium dieback at Sannyashithan tea garden and data analysis. Evaluation of bacterial isolate(s) and *Trichoderma* against *Fusarium* dieback, grey blight, and red rust at Jiti tea garden and data analysis. **April 2022- June 2022** • Purification and multiplication of cultures for field trials. • Molecular identification of potential cultures • Study of physiological traits of efficient microbes. • Multiplication of Path01 and OK01 for evaluation against red rust under field conditions. • Study of growth of both bacterial species at different temperature • Multiplication of TRPATH01 for its plant growth promotion activity. Publication: Pandey AK et al. (2022) Mycotoxins along tea supply chain: a dark side and an ancient and high valued aromatic beverages; Critical Review in Food Science and Nutrition.	
Biochemistry					
22. Screening of	Dr. B.	Investigations by Dias *et. al.*	Selection of	**January – June, 2020**	Date of start

cultivars and optimization of process parameters for white tea under North Bengal condition.	Adhikary	(2013),Unachukwu, *et. al.* (2010), Hilal, *et. al.* (2007) have associated white teas with anti-carcinogenic, immune-boosting, and anti-oxidative properties that may impact human health in a manner comparable to green teas. No reported work on white tea for this region.	suitable cultivars for white tea with desirable quality attributes. Ascertain the chemical composition of white teas from region-specific cultivars of NorthBengal.	As advised by Director sir, a few white tea samples were processed and sent to TTRI, TRA Jorhat for further analysis as a part of the their in-house project and joint collaborative work. **(Project completed)**	(2016) Likely date of completion (2020)
23. Biochemical investigation of Darjeeling orthodox teas with special emphasis on aroma components **(New Proposal)**	Dr. B. Adhikary & Dr. B. Kashyap	Hazarika *et. al.* (1984) have reported that there were well marked variation in VFC's of orthodox Darjeeling teas due to differences in weather conditions during the growth period and manufacturing techniques. Ravichandran *et. al.*, (1998) reported that during black tea processing, Group-I VFC, increases rapidly during withering & fermentation and then decreases sharply during drying, while Group-II VFC, remains at a high level during the drying, resulting in a rapid increase in the flavor index in the dry tea. As reported by Mahanta *et. al.*, (1989), hard withering is deleterious to the sensory quality of black tea. In the present scenario, research	i). Optimization of processing parameters for orthodox black tea under Darjeeling condition to get desirable flavor constituents in the finished product. ii). Monitoring the seasonal variation of chemical and flavor constituents in orthodox teas iii).Biochemical and organoleptic evaluation of the processed tea and correlation with flavor constituents.	**February – June 2020** The Comments of the mentors with suggested incorporations do not match the project proposal, which may be noted and a revised comment with suggestions to be sent for incorporation in the project proposal. Research work could not be initiated due to lockdown because of Covid-19 pandemic and shall have to wait till the situation normalizes and research activities can be resumed. Yet to receive the allotted fund of Rs. 4,00,000/- for 1st year from the total allotted fund of Rs. 800000/- **July- September 2020 (Q3)** As suggested, a few processing trials on effect of withering, fermentation temperature and humidity on quality were conducted in the ECM unit at our miniature factory, related to black and green teas during the rain and autumn flush. Biochemical data analysis is in progress. Samples will be sent to TTRI	Date of start (2020) Yet to start Likely date of completion (2023) Total Budget: Rs.8.00lakhs No funds received as on 13th July, 2020

		work on Darjeeling orthodox tea needs to be initiated.		for organoleptic evaluation. **Status up to March, 2021** • Processed black teas were analyzed for quality parameters and tasting report collected from TTRI, TRA. • A commercial garden has been selected for the trials. First flush orthodox tea samples were collected from the garden, which will be sent for further analysis. **March, 2021-June 2021** • Processed black teas were analyzed for quality parameters and tasting report collected from TTRI, TRA. **July, 2021-December, 2021** Biochemical investigation of Darjeeling orthodox teas with special emphasis on aroma components' orthodox black tea samples for the month of July, August & September, October, November, 2021 have been collected from the commercial factory and processing conditions noted. Samples have been sent for organoleptic evaluation. **January to March 2022 (Q1)** The factory processed black orthodox tea samples were analyzed for non-volatile quality components TF/TR & results have been tabulated. Tea samples along with the Internal standard (ethyl decanoate) for VFC analysis have been sent to Analytical department, TTRI, TRA, Jorhat of VFC. Method standardization by 'Solvent extraction' is in progress. Estimation of biochemical quality parameters for all tea samples under various collaborative inhouse projects has been done.	

				The renovation work of the miniature clonal tea factory is in progress. **April-June 2022 (Q2)** Black orthodox tea samples were collected from gardens during first flush, processing condition noted, analyzed for TF/TR, Caffeine, Catechin fractions & organoleptic evaluation was done. Method standardization by 'Solvent extraction' is still in progress at TTRI, Jorhat. Extraction apparatus will be required if solvent extraction doesn't give promising results. Estimation of biochemical quality parameters for all tea samples under various collaborative in-house projects is being done. The renovation work of the miniature clonal tea factory is in progress, POs for various machineries have been placed.	
Soil					
24. Application of humic substrate solution to reduce N and K fertilizer application rates in soil during tea cultivation **(New**	Dr. Prabhat Pramanik	Understanding of the nature of HA indicates that they are complex associations of small polydispersed mixtures of heterogeneous polyelectrolytes, and behave as a weak polyelectrolytic acid that can be investigated by analytical techniques. Most of the acidity in the HA is due to the carboxylic, phenolic-OH and/or enolic groups which dissociate to develop negative charges in a wide pH range. The degree, at	The overall objectives of this study are to • Evaluate the effect of application of humic substrates on the availability of nitrogen and potassium in soil • Optimize an integrated nutrient	**April – June 2020 (Q2)** ○ Protocol of the study is prepared ○ Field in a commercial tea garden is selected and the experiment will be initiated in August month. Financial Support required in the 1st Year: INR 27,500/- **July-Sept, 2020 (Q3):** ○ For large-scale Humic acids extraction from tea waste, a system suitable for recycling 100 kg tea waste is established in commercial tea garden. The process will be continuous and the estimated	Date of start: March 2020 Likely date of completion: 2022

Proposal)		which these groups are ionized or protonated, depends on the environmental pH values. Their abundance and distribution have a significant influence in the interaction between HA and a wide range of substances (Machesky, 1993; Ritchie and Perdue, 2003; Plaza et al., 2006). Therefore, a better knowledge of the chemical and physicochemical properties of HA will contribute to understand the mechanisms that control an optimum supply of the nutrients for chemical and physicochemical properties as well as many soil physical and chemical characteristics are affected by the organic amendment application (Christl and Kretzschmar, 2001; Garcia-Gil et al., 2004).	management practice involving humic substrates to reduce the doses of urea and MoP application	time required to complete each cycle is 60 days. ○ Process is already started and extracted acid solution is collected in the tanks. The process is expected to produce approximately 1800 L Humic acid solution after each cycle of 60 days. A total 6 cycles of Humic acid extraction could be completed in a year. **Status up to March, 2021** • The humic substrate samples, collected from Kurti TE and Aibheel TE, are analyzed and the reports are shared with the concerned gardens. • The humic substrate preparation unit is also initiated in TRA Nagrakata. • Humic substrate solution, those were prepared in Kurti TE and Aibheel TE, were applied in soil of respective gardens. • The brief procedure is shared with several tea gardens as they were interested to establish the humic substrate extraction unit in their gardens. **March, 2021-June 2021** • The humic substratecollected from the unit is in TRA Nagrakata has also been analysed for the quality. • Soil samples were collected from Kurti TE and Aibheel TE, from the plots applied with humic substrates **July, 2021-December, 2021** • The methodology of preparing humic substrate solution from tea waste is disseminated among the interested tea gardens.	Total Budget: Rs 0.75lakhs No fund received as on 13th July, 2020

				• Samples of prepared humic substrate solution of different tea gardens were analyzed for estimating quality of the product. And the necessary guidance is provided if and when the quality of the prepared humic substrate solution was not within the desired limits. • Prepared humic substrate solution was applied in soil of different tea gardens and post-application soil samples were collected for evaluating changes in soil chemical properties. • Humic substrate solution was applied at different doses (higher dilution) on the foliar of tea bushes and shoot yield data are recorded periodically. **January – March, 2022 (Q1)** • Soil samples were collected from humic substrate treated sections of different tea gardens were analyzed and the data were compared against the pre-treatment soil data. • It was observed that soil pH was not affected due to application of humic substrate solution. • Availability of potash was significantly increased after application of humic substrate solution in soil. • Availability of nitrogen in soil was also increased due to application of humic substrate solution. • A questionnaire is circulated among the tea gardens who adopted this humic substrate work for getting their feedback. **April – June, 2022 (Q2)** The project is completed.	
Tea Processing and Manufacturing Advisory Tocklai					
25. Impact of prolonged storage of green leaf	Mr. R. C. Gogoi	Withering involves both chemical and physical changes. During withering this reduces to about 68–72% or 60–66%	a) Technology to store harvested shoots for longer duration	**March – June 2020** **Approval awaited**	

and made tea on quality **(New Proposal)** As per Engineering Committee recommendation, the project was renamed as, "To study and identify parameters and their operating ranges to minimize the loss in quality during transportation"		for maceration with the cut–tear–curl method or with the orthodox method, respectively. Time, temperature and relative humidity (RH) of withering have significant effects on the final product quality. A positive correlation has been found between the quality of made black tea and the catechin composition in fresh leaves of various cultivars. The amount of EGC, GC, ECG and EGCG decreases during withering, whereas EC increases. It was reported that the increase in EC might be related to the degradation of EGCG. Because of the loss of moisture, the PPO activity reduces during withering or storage of the fresh leaves. Very hard withering or high reduction of moisture could result in as high as 50–55% reduction in PPO activity. As there occurs many chemical and physical changes during withering that directly or indirectly affect the final quality of black tea, it is crucial to control these changes during withering. Tea leaves have a considerably long shelf-life due to their low moisture content. Storage for an	without deterioration of quality. b) Reduction in overload of poor quality tea in the market. c) Knowledgebase on ideal storage conditions for made tea.	**Q2 July – September 2020** The project was approved by TRA Engineering Committee meeting held on 24th July, 2020(approved minutes circulated on 19th Aug), with the following modification: Instead of storage of green leaf, the focus of study should be on to identify parameters and their operating range to minimize the loss in quality during transportation. Miniature level experimental trials were initiated to store green leaf in perforated hardboard boxes (16" x 13" x 7") in varying packing densities and timeperiods. **October – December 2020 (Q3)** The miniature level experiments were repeated with variation in the treatments. Treatments of lower temperatures showed encouraging results. **Q4 January - March 2021** The experiments were performed in the following manner – Control - The perforated cardboard boxes (16" x 13" x 7") loaded with green leaf @ 3.5 kg were stored in ambient conditions for period of 8 to12 hrs. Experiment – (a) Same sized perforated cardboard boxes loaded with green leaf @ 3.5 kg stored at lower temperatures of 4^0C & 0^0C for same period as like control. The leaves were then withered in ambient conditions	

		extended period of time can lead to loss of quality of the product. It was reported that tea catechins are not stable during long-term storage. ECG may be more susceptible to degradation than EGCG. Storage of black tea for up to 12 months can affect theaflavins and thearubigins content. The loss of theaflavins was greater for orthodox black tea (around 37%) than for CTC (22%), whereas for thearubigins the relation was opposite. It was indicated that γ-irradiation could reduce this deterioration to a great extent. The main factors influencing tea quality and catechin stability during storage are light, oxygen, and temperature. The optimal storage conditions to maintain catechin stability were indicated by Li *et al.* as ambient temperature and relative humidity below 43% or in a freezer at relative humidity below 60%. Also, There is a great influence of packaging material on storage stability. Catechins were found to be stable up to 6 weeks in tea stored in the absence of light at a temperature of 3°C. After that the degradation appeared to a		for 8 hours. Initial findings: Control samples showed bruise & damage up to 18%. Similarly, experimental samples stored at 0^0C showed scorching & damage. However, it was observed that leaf stored at 4^0C showed damage around 4%. Further trials are planned to be carried out this season. **Q1 April – June 2021** During this quarter, Organoleptic assessment of the made tea samples were carried out. (1) Control samples (under ambient conditions) showed brownish appearance and contained smaller grades, lacked bloom, plain, coloury & soft with damage smell. (2) Samples stored at 0^0C were dual in appearance, harsh with damage smell. (3) While leaf stored at 4^0C produced Bl/Br fairly good grade mix, bloomy and fairly bright. A system with perforated PVC pipes was designed and accordingly a unit was fabricated in which compressed humidified air was made to pass through the stored leaf. Experimental trials are planned during the season. **Q4 Till December 2021** Miniature level trials were initiated to store green leaf in perforated cardboard boxes (16” x 13” x 7”) in varying temperatures and time periods. Initial	

		greatest extent in retortable pouch > PET > glass. It was reported that cold storage at 4°C of tea beverages in PET bottles ensures a slower decrease in catechin content in white, black, and green teas.		findings showed that control samples were bruise & damage up to 18%. Similarly, experimental samples stored at 00C showed scorching & damage. However, leaf stored at 40C showed damage around 4%. Next, a system with perforated PVC pipes was designed and accordingly a unit, using plyboard box of 24" x 24" x 48", was fabricated in which compressed humidified air was made to pass through the stored leaf. This new 'transportation cum storage' prototype is ready for trials to check its performance. **January - March 2022 (Q1)** Two looksee trials were carried out with the newly fabricated prototype 'transportation cum storage' device. Fresh trials are to be initiated in the forthcoming season. **April – June 2022 (Q2)** Trials initiated with the 'transportation cum storage' device installed at the miniature factory. While conducting trials some modifications were felt necessary to the humidification duct. Necessary rectifications on the machine are nearing completed. Fresh trials are to be initiated from July.	
26. Estimation of grade percentage through image processing	Mr. S. Sanyal	While grading CTC tea, the made tea is sorted into different grain sizes by passing it over a series of vibrating sieves of different mesh sizes. The larger the leaf particle, slower it brews (or infuses) and smaller the	a) Online estimation of grade percent during CTC manufacturing. b) Optimisation of remunerative	**March – June 2020** **Approval awaited** **July – September 2020 (Q3)** The project was approved by TRA Engineering Committee meeting held on 24th July, 2020 (approved	

(New Proposal)		pieces the faster it infuses. Additionally, color, briskness, strength, clarity – practically all the market oriented quality parameters depends upon the grade. This renders different grades being differently remunerative. Therefore, there is a constant effort to optimize the grade percentage in order to maximize the revenue. Some of the variables that impact the granulation and quality of tea, are extent of wither, CTC roller specifications, condition of CTC roller sharpness and most importantly, the hardness of cut in CTC. As the size of the tea granules is important in terms of quality and revenue, it can be addressed by the image texture analysis methods of computer vision. The images of various granule sizes at the CTC stage of processing would be different by texture. Texture has long been an important research topic in computer vision and image processing. According to human perception theory, many parts of an image are recognized by texture rather than by shape, for example grass, hair, water, fur etc. Texture analysis has found wide application in areas such	grades during production.	minutes circulated on 19th Aug). Discussion was held with Controlytix, Chennai. One stand-alone offline device was decided to be fabricated by them. The offline device will be installed at Tocklai for data collection. **October – December 2020 (Q4)** Fabrication of the offline device is in progress. Controlytixteam is expected to visit TTRI for site selection. **Q4 January - March 2021** Personnel from Controlytix visited MTF, TTRI in Feb 2021. It was decided to install the offline imaging device at MTF after its fabrication. There is delay in fabrication of the offline imaging device due to non-availability of some internal parts. **Q1 April – June 2021** Till arrival of the offline imaging device from Controlytix, Chennai, images of the 'dhool' from CTC belts were taken with ordinary camera. The variations in treatments applied were hard cut, medium cut & light cut with hard withered, optimum withered and under withered coarse leaf. The images were forwarded to Controlytix for analysis. An offline imaging microscope has been dispatched by Controlytix. Arrival awaited. **Till December 2021 Q4**	

		as remote sensing, medical diagnosis, quality control, food inspection and so forth. The texture analysis is considered to play a critical role in automatic grading process in some food industries, where the size of the object is the discriminating parameter. To select a suitable method of texture discrimination among the images, the human perspective of differentiating between the tea granule sizes can be conjugated. So, such texture analysis method would be worthwhile in estimating the tea granule size by classifying the texture into their appropriate categories. This in turn helps in monitoring the grading process during manufacture and more importantly, before final tea is made.		Images of 'dhool' from CTC belts were captured with ordinary camera. The images were forwarded to Controlytix for analysis. Initial imaging of dhool from CTC belts was captured with the varying parameters i.e., fine (>65%), optimum, coarse (<45%), wither percentage and hardness of CTC cut. Further, an offline imaging microscope has been procured and installed at MTF. The imaging microscope is being used for collection of images from CTC and CFM beds. **January - March 2022 (Q1)** A fixture was designed & fabricated to facilitate offline imaging with the digital microscope. The system will be deployed at MTF to capture images from CTC and CFM beds, in the coming season. **April – June 2022 (Q2):** Work on installation and fitting of the digital microscope at MTF is initiated. The above project has been submitted MietY (Deptt. Of Science & Technology, GOI) in collaboration with C-DAC and Jadavpur University, Kolkata.	
27. Development of portable spectroscopes and its application for estimation of	Mr. A. K. Hazarika	The quality or perception of tea is a multi-component measure of various types of inherent chemical components present in the fresh tea shoots. During processing, polyphenols present in the cell vacuole are oxidised by oxidative enzymes in the tea, leading to the formation of	Spectroscopic models for estimation of catechin, amino acid and theaflavin in tea with portable low-cost	**March – June 2020** **Approval awaited** **July – September 2020 (Q3)** The project was approved by TRA Engineering Committee meeting held on 24th July, 2020(approved minutes circulated on 19th Aug).	

quality compounds in tea **(New Proposal)**		characteristic black tea pigments, theaflavins (TF, golden yellow) and thearubigins (TR, orangey brown), which are largely responsible for briskness, brightness, strength and colour of finished teas. The objective evaluation of some of these key biochemical quality markers in tea would serve as an acceptable quality monitoring and measurement tool. During the last few decades, the application of computer/electronics and spectroscopic techniques has been a growing area of research in making subjective judgments of some biochemical quality attributes in tea. If a sample contains chemical bonds such as C-H, N-H or O-H and if the concentration of analyte exceeds 0.1% of the total composition, the method is likely to yield acceptable answers, even in the hands of relatively untrained personnel. Mathematical models based on statistical analysis have been developed to assess interactions between the spectrum and the property evaluated to calibrate the apparatus. International Status:	instrument.	An online discussion was held with Prof. R. Bandyopadhyay and his team of Jadavpur University, Kolkata. They agreed to help us carry out spectroscopic scans of tea samples for development of NIR methodology for estimation of theaflavin (TF) in black tea. Simultaneously, biochemical and organoleptic evaluations will be carried out at Tocklai. **October – December 2020 (Q4)** 15 sets of tea samples were processed. One set was sent to Jadavpur University for spectroscopic data acquisition, while the other two sets were sent for biochemical and organoleptic evaluations. The project has been freshly submitted to BIRAC DBT for funding. **January - March 2022 (Q1)** The project was approved for funding by DBT (BIRAC)-GOI for a period of 18 months. R & D progress under this project is reported under 'Externally funded projects' starting from this quarter. **March – June 2022 (Q2):** As reported in quarter 1, R & D progress is reported under 'Externally funded projects'.	

		Application of Raman and NIR spectroscopy as simple, quick and accurate quality assessment tool to identify the variety of tea quantitatively has become an important assignment for analysers in Western countries as-well-as countries like Japan, China, Korea. Computer and electronic technologies are fast, reliable and can consistently perceive the aroma, flavor, colour and chemical parameters of tea leaves. Feasibility studies on the application of NIR for qualitative and quantitative analysis of intrinsic attributes, like polyphenols, catechins, gallic acid, caffeine and theobromine in tea leaves have been reported. Researchers have successfully utilized NIR spectroscopy for tea variety discrimination, dry matter content in tea, caffeine, theaflavin and moisture content in black tea, simultaneous analysis of alkaloids and phenolic substances in green tea leaves and also the market price of tea. National status: Several institutes in India are engaged in research on electronic and spectroscopic methods for quality analysis of various			

		agricultural crops namely CSIO-Chandigarh, NPL-New Delhi, CEERI-Chennai, CDAC-Kolkata, IIT Kharagpur. Electronic and spectroscopic techniques have been gainfully employed in the areas of tea leaves moisture monitoring, percentage of withering of tea leaves, drying status and relative humidity during withering and also in predicting the optimum fermentation time. Studies using e-vision have been carried out in North East India, using image processing technique and computer based colour matching system for non-destructive testing of tea fermentation. Mishra et. al. estimated the caffeine content in instant green tea powder using FT-NIR spectroscopy. Most of the publications have focused on the application feasibility of NIR for qualitative and quantitative estimations of tea constituents, especially in green teas. A meaningful and consistent NIR spectroscopic methodology will only be acceptable to the tea industry if it can be applied for *in situ* estimations of tea leaves. There are also relatively few studies on black tea processing,			

		especially fermentation monitoring and quality monitoring of finished teas relevant to North-East Indian conditions.			
28. Application of portable spectroscopic instruments for on-site estimation of quality compounds in tea	Dr. A. K. Hazarika	The quality or perception of tea is a multi-component measure of various types of inherent chemical components present in the fresh tea shoots. During processing, polyphenols present in the cell vacuole are oxidized by oxidative enzymes in the tea, leading to the formation of characteristic black tea pigments, theaflavins (TF, golden yellow) and thearubigins (TR, orangey brown), which are largely responsible for briskness, brightness, strength and colour of finished teas. The objective evaluation of some of these key biochemical quality markers in tea would serve as an acceptable quality monitoring and measurement tool. During the last few decades, the application of computer/electronics and spectroscopic techniques has been a growing area of research in making subjective judgments of some biochemical quality	Spectroscopic models for estimation of catechin, amino acid and theaflavin in tea with portable low-cost instrument.	**Q1 March – June 2020** Approval awaited. **Q2 July – September 2020** The project was approved by TRA Engineering Committee meeting held on 24th July, 2020 (approved minutes circulated on 19th Aug). An online discussion was held with Prof. R. Bandyopadhyay and his team of Jadavpur University, Kolkata. They agreed to help us carry out spectroscopic scans of tea samples for development of NIR methodology for estimation of theaflavin (TF) in black tea. Simultaneously, biochemical and organoleptic evaluations will be carried out at Tocklai. **Q3 October – December 2020** 15 sets of tea samples were processed. One set was sent to Jadavpur University for spectroscopic data acquisition, while the other two sets were sent for biochemical and organoleptic evaluations. **Q4 January - March 2021** At present, theaflavin (TF) concentration in black tea	

		attributes in tea. If a sample contains chemical bonds such as C-H, N-H or O-H, the method is likely to yield acceptable answers, even in the hands of relatively untrained personnel. Mathematical models have been developed to assess interactions between the spectrum and the property evaluated to calibrate the apparatus. International Status: Application of Raman and NIR spectroscopy as simple, quick and accurate quality assessment tool to identify the variety of tea quantitatively has become an important assignment for analyzers in Western countries as-well-as countries like Japan, China, Korea. These electronic technologies are fast, reliable and can consistently perceive chemical parameters of tea leaves. Feasibility studies on the application of NIR for qualitative and quantitative analysis of intrinsic attributes, like polyphenols, catechins, gallic acid, caffeine and theobromine in tea leaves have been reported. Researchers have successfully utilized NIR spectroscopy for tea variety discrimination, dry matter		has been taken as the quality biomarker for evaluation by NIR Spectroscopic technique. Another set of 15 new samples were prepared for analysis to develop the Chemometric algorithm for TF with the imported spectroscope from StellerNet, USA, already available at Jadavpur University, Kolkata. An external project has been approved to support development of indigenous NIR spectroscope with associated chemometric algorithm for TF. The project period is for 18 months. **Q1 April – June 2021** NIR spectral data acquisition of 28 samples was done in diffused reflectance mode for TF estimation. A model was developed using PLS regression algorithm. Preliminary results show RMSECV, RPD and R^2 values of .056, 3.54 & 0.92 respectively. The results were encouraging. Samples are under preparation for further analysis. **Q4 Till December 2021** Under this project, estimation of theaflavin (TF) concentration in black tea has been taken as one of the quality bio-marker using NIR spectroscopic technique. Spectral data acquisition of 28 samples was done in diffused reflectance mode. A model was developed using PLS regression algorithm after pre-processing by SNV. Preliminary results show RMSECV, RPD and R2 values of .056, 3.54 & 0.92 respectively, which are encouraging despite the fact that the number of samples were quite less.	

		content in tea, caffeine, theaflavin and moisture content in black tea, simultaneous analysis of alkaloids and phenolic substances in green tea leaves and also the market price of tea. National status: Several institutes in India are engaged in research on electronic and spectroscopic methods for quality analysis of various agricultural crops namely CSIO-Chandigarh, NPL-New Delhi, CEERI-Chennai, CDAC-Kolkata, IIT Kharagpur. Electronic and spectroscopic techniques have been gainfully employed in the areas of tea leaves moisture monitoring, percentage of withering of tea leaves, drying status and relative humidity during withering and also in predicting the optimum fermentation time. Most of the publications have focused on the application feasibility of NIR for qualitative and quantitative estimations of tea constituents, especially in green teas. A meaningful and consistent NIR spectroscopic methodology will only be acceptable to the tea industry if it can be applied for *in situ* estimations of tea leaves.		To improve the performance of the NIR model, new samples were prepared for further analysis and populate the dataset. Further, organoleptically assessed values from the new dataset are also to be included in the chemometrics model to make the NIR prediction model more comprehensive. **January - March 2022 (Q1)** In this quarter, 40 nos. of black CTC tea samples were analyzed. Biochemical values and organoleptic quality estimates were sent to collaborating institute for correlations with spectroscopic data. **March – June 2022 (Q2):** A project "Development of portable spectroscopes and its application for estimation of quality compounds in tea" was approved for funding by DBT (BIRAC)-GOI for a period of 18 months. All experimental and analytical work is reported under 'Externally funded projects' starting from this quarter.	

		There are also relatively few studies on black tea processing, especially fermentation monitoring and quality monitoring of finished teas relevant to North-East Indian conditions.			
29. Design and development of low-cost tea drier for Small Tea Growers **(New Proposal)**		The demand for green tea in domestic market is growing at 17 per annum as against only 3% for black tea. Green tea produced in Assam is typically heat-treated by steaming or panning immediately after harvest. It is then rolled and dried repeatedly. The two most vital processing steps of green tea are deactivation of fresh leaves, which generally done by steaming (Japanese method) or panning (Chinese method), and then drying, which done in conventional ECP driers or panner/roaster. All these machines are available in India and prices vary depending upon leaf handling capacity and sophistication. From our survey, the price of steaming units starts from 2 lakh and above. Conventional diesel/coal fired Endless Chain Pressure (ECP) driers costs around 10 lakhs. While, panning machines, imported or	a) Low-cost and energy efficient prototype deactivation cum drying machine for STG manufacturing units. b) Cost effective drying technique	**March – June 2020** **Approval awaited** **July – September 2020 (Q3)** The project was approved by TRA Engineering Committee meeting held on 24th July, 2020(approved minutes circulated on 19th Aug). To meet up the requirement of low-cost drier for drying handmade teas for STGs, a local fabricator from Jorhat and another from Kolkata, were contacted for fabrication. Financial modalities for fabrication of the same are being worked out. **October – December 2020 (Q4)** Quotations are awaited from the fabricators. **Q1 January - March 2021** Quotations from two local fabricators were received till date. Detailed breakup prices were not mentioned in both quotations. Parties were intimated to resubmit accordingly.	

		otherwise, available in the market ranges from 3 to 6 lakhs and above. The advantage of panners are that these can be used for both deactivation and drying of tea leaves. It is observed that most STGs manufacture green teas in small quantities. There are reports that green teas produced by a few STGs fetch high prices. Some producers have also gained from good reputation in the international market. But, overall, most green teas produced by STGs do not meet the minimum quality standards and fail to qualify as niché tea even in the domestic market. While the lack of exposure and awareness is responsible to a large extent, shortcomings in the process technology and suitable capacity of machines for this scale of production also contribute towards failure. Work in this line was initiated by TTRI in a collaborative project funded by National Tea Research Foundation. Under this project, a prototype machine for quick preparation (deactivation-drying-grinding-sieving) of green tea samples (20 – 50 gms), was designed and developed. Preliminary		**Q2 April – June 2021** During this quarter, a modified form of a mini tray-type drier with capacity of 2 to 3 kg leaf (per batch) was conceived. The drier is now under fabrication by a local fabricator. **Till December 2021 Q4** A basic form of a tray-type drier with capacity of upto 5 kg green leaf per batch was designed. The prototype was locally fabricated and installed at the miniature factory, Tocklai for trials with backend crop. **March – June 2022 (Q2):** After two initial trials, issues of uneven drying of the green tea dhool were observed. A fault with the heat distribution arrangement was identified. In-house fabrication of the heating system and blower arrangement is undergoing. Fresh trials will be initiated on rectification of the system.	

		investigations were also carried out (in-house) to compare the variations in biochemical quality parameters of green teas prepared by four methods, viz. steaming, panning, hot-water treatment and microwave. The machine mentioned above served the purpose of the project well to prepare small quantities of leaves for analysis; But major design modifications, additional features and refinements would be necessary to upgrade it to a commercial green tea processing unit.			